Appendix D

Results of the February and March 2003 Echo Integration-Trawl Surveys of Walleye Pollock (*Theragra chalcogramma*) Conducted in the Gulf of Alaska, Cruises MF2003-01 and MF2003-05

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INTRODUCTION

Scientists from the Midwater Assessment and Conservation Engineering (MACE) Program of the Alaska Fisheries Science Center (AFSC) routinely conduct echo integration-trawl (EIT) surveys in the Gulf of Alaska (GOA) during late winter and early spring to estimate walleye pollock (*Theragra chalcogramma*) distribution and abundance. Most of the effort has focused on the Shelikof Strait area, which has been surveyed annually since 1980, except in 1982 and 1999. Large amounts of pollock were also detected in the Shumagin Islands area in 1994-96 and 2001-02 and along the GOA shelf break east of Chirikof Island in 2002. Results presented here are from EIT surveys carried out in February and March 2003. The first survey period occurred between 5-12 February 2003 in the Shumagin Islands and Sanak Trough (Cruise MF2003-01). The second survey period occurred between 16-31 March 2003 in the Shelikof Strait area and in two areas along the GOA shelf break near Chirikof Island and Middleton Island (Cruise MF2003-05).

METHODS

Shumagin Islands/Sanak Trough Itinerary

5 Feb	Embark scientists in Kodiak, AK.
6 Feb	Calibration of acoustic system in Alitak Bay, AK.
7-9 Feb	EIT survey of the Shumagin Islands.
10 Feb	EIT survey of Sanak Trough.
12 Feb	Arrive Kodiak, AK; disembark scientific party; end of cruise.

Shelikof Strait Itinerary

14-15 Mar	Transit to Shelikof Strait.
16-22 Mar	EIT survey of the Shelikof Strait area.
22 Mar	Arrive Kodiak, AK.

Shelf Break Itinerary

23 Mar	Exchange portion of scientific party.
24 Mar	Depart Kodiak, AK.
25-27 Mar	EIT survey of the Chirikof Island area.
28-29 Mar	EIT survey of the Middleton Island area.
30 Mar	Transit to Yakutat Bay, AK; calibration of acoustic system in Sea Otter Bay, AK.
31 Mar	Arrive Yakutat, AK; disembark scientific party; end of cruise.

Acoustic Equipment

Acoustic data were collected with Simrad EK500[1] and Simrad EK60 quantitative echo-sounding systems (Simrad, 2001; Bodholt et al. 1989, Bodholt and Solli 1992) on the NOAA ship *Miller Freeman*, a 66-m stern trawler equipped for fisheries and oceanographic research. Three split-beam transducers (38 kHz, 120 kHz, and 200 kHz) were mounted on the bottom of the vessel's retractable centerboard extending 9 m below the water surface. System electronics were housed inside the vessel in a permanent laboratory space dedicated to acoustics. Simrad EK500 data (38 and 120 kHz) and Simrad EK60 data (200 kHz) were logged with SonarData EchoLog 500. The 38 kHz data were analyzed using SonarData Echoview (Version 2.25.109) PC-based post-processing software. Echo integration and target strength data were collected simultaneously at all frequencies. Results presented here are based on the 38 kHz data.

Trawl Gear

Midwater and near-bottom echosign was sampled using an Aleutian Wing 30/26 Trawl (AWT). This trawl was constructed with full-mesh nylon wings, and polyethylene mesh in the codend and aft section of the body. The headrope and footrope each measured 81.7 m (268 ft). Mesh sizes tapered from 325.1 cm (128 in) in the forward section of the net to 8.9 cm (3.5 in) in the codend. The net was fitted with a 1.3-cm (0.5-in) codend liner for all surveys except for the Shelikof Strait survey, for which a 3.2-cm (1.25-in) codend liner was used. The AWT was fished with 82.3 m (270 ft) of 1.9-cm (0.75-in) diameter (8x19 wire) non-rotational dandylines,

[1] Reference to trade names or commercial firms does not constitute U.S. Government endorsement.

226.8-kg (500-lb) or 340.2-kg (750-lb) tom weights on each side, and 5 m^2 Fishbuster trawl doors [1,247 kg (2,750 lb) each]. Vertical net opening and depth were monitored with either a Wesmar third-wire or Furuno netsounder system attached to the trawl headrope. The vertical net opening for the AWT trawl ranged from 16-32 m (52-105 ft).

Demersal echosign was sampled with a poly nor'eastern bottom trawl (PNE) with roller gear. The PNE is a high-opening trawl equipped with roller gear and constructed with stretch mesh sizes that ranged from 13 cm (5 in) in the forward portion of the net to 89 mm (3.5 in) in the codend. The codend was fitted with a 3.2 cm (1.25 in) nylon mesh liner. The 27.2-m (89.1-ft) headrope held 21 floats [30-cm (12-in) diameter]. A 24.7-m (81-ft) chain fishing line was attached to the 24.9-m (81.6-ft) footrope which was constructed of 1-cm (0.4-in) 6 x 19 wire rope wrapped with polypropylene rope. The trawl was also rigged with triple 54.9-m (180-ft) galvanized wire rope dandylines. The roller gear was attached to the fishing line using chain toggles [2.9 kg (6.5 lb.) each] which were comprised of five links and one ring. The 24.2-m (79.5-ft) roller gear was constructed with 36-cm (14-in) rubber bobbins spaced 1.5 to 2.1 m (5 to 7 ft) apart. A solid string of 10-cm (4-in) rubber disks separated some of the bobbins in the center section of the roller gear. Two 5.9-m (19.5-ft) wire rope extensions with 10-cm (4-in) and 20-cm (8-in) rubber disks were used to span the two lower flying wing sections and were attached to the roller gear. The net was fished with the 5 m^2 Fishbuster trawl doors. The vertical net opening and depth were monitored with a Furuno netsounder system attached to the headrope. The PNE trawl vertical mouth opening ranged from 6-8 m (20-26 ft).

Oceanographic Equipment

Physical oceanographic data collected during the cruise included temperature/depth profiles obtained with a Sea-Bird Electronics temperature-depth probe (SBE-39) attached to the trawl headrope and conductivity-temperature-depth (CTD) observations collected with a Sea-Bird CTD system at calibration sites. Sea surface temperature, salinity, and other environmental data were collected using the *Miller Freeman's* Scientific Computing System (SCS). Ocean current profile data were obtained using the vessel's centerboard-mounted acoustic Doppler current profiler system operating continuously in bottom-tracking mode during the Shumagin Islands and Shelikof Strait surveys and in water-profiling mode during the shelf break survey.

Survey Design

Parallel transect designs were used for all areas. The Shumagin Islands were surveyed between 7 and 9 February. Transect spacing was 9.2 km (5 nmi) in Shumagin Trough, 5.5 km (3 nmi) in Stepovak Bay and West Nagai Strait, 4.6 km (2.5 nmi) in Unga Strait, and 1.8 km (1 nmi) east of Renshaw Point (Fig. 1). Bottom depths did not exceed 220 meters along any transect, and transects generally did not extend into waters shallower than about 50 m depth. Sanak Trough was surveyed on 10 February using transects spaced 5.5 km (3 nmi) apart. Bottom depths did not exceed 160 meters along any transect, and transects generally did not extend into waters less than about 50 m depth. The Shelikof Strait sea valley was surveyed from south of Chirikof Island to about Cape Chiniak on the Alaska Peninsula between 16 and 22 March using 13.9 km (7.5 nmi) transect spacing (Fig. 2). Transects generally did not extend into waters shallower than about 100 m depth. A survey of the shelf break southeast of Chirikof Island to the mouth of Barnabas Trough was conducted between 25 and 27 March along 14.8 km (8 nmi) spaced transects (Fig. 2). The shelf break near Middleton Island was surveyed between 28 and 29 March using transects spaced 9.3 km (5 nmi) apart (Fig. 3).

Trawl hauls were conducted to identify echosign, to provide biological samples for the primary goals of the survey, and to collect specimens for additional research projects such as fecundity and genetic studies. Average trawling speed was approximately 1.5 m/s (3 kts). Pollock were sampled to determine sex, fork length (FL), body weight, age, maturity, and ovary weight of selected females. Fork lengths were measured to the nearest cm. An electronic motion-compensating scale was used to weigh individual pollock specimens. For age determinations, pollock otoliths were collected and stored in 50% ethanol-water solution. Maturity was determined by visual inspection and categorized as immature, developing, pre-spawning, spawning, or post-spawning. All data were electronically recorded using the Fisheries Scientific Computing System (FSCS) and stored in a relational database. Additional samples of pollock tissue, ovaries, and stomachs were collected for ongoing research by AFSC scientists. Whole fish were retained for the AFSC's Observer Program training specimens.

Standard sphere acoustic system calibrations were made before cruise MF2003-01 and before and after cruise MF2003-05 to measure acoustic system performance for the EK500 at 38 and

120 kHz and for the EK60 at 200 kHz. During the calibrations, the *Miller Freeman* was anchored at bow and stern. Three calibration spheres were suspended below the centerboard-mounted transducers: a 23-mm diameter copper sphere with a target strength (TS) of -40.3 dB at 120 kHz, a 60-mm diameter copper sphere with a TS of -33.6 dB at 38 kHz, and a 38.1-mm diameter tungsten carbide sphere with a TS of -39.5 dB at 200 kHz. Split-beam target strength and echo integration data were collected with each sphere centered on the acoustic axis to determine acoustic system gain parameters. The beam pattern was estimated by moving each sphere through a grid of angle coordinates and collecting TS data using the Simrad software program EKLOBES (Foote et al. 1987).

Data Analysis

Echo integration data were collected between 14 m of the surface and 0.5 m of the bottom, except where the bottom exceeded 1,000 m, the lower limit of data collection. Echosign data identified as pollock were stored in a relational database. Pollock length data were aggregated into analytical strata based on echosign type, geographic proximity of hauls, and similarity in size composition data. Estimates of pollock backscattering strength for each stratum were then calculated using an S_v threshold of –69 dB. The echo integration values were summed and scaled using a previously derived relationship between target strength and fish length (TS = 20 Log FL - 66; Traynor 1996) and the length composition data to produce estimates of pollock numbers by length. Biomass estimates by length were calculated using the length-weight relationships calculated from the trawl data for each of the areas sampled Age-specific estimates of biomass and numbers will be generated after the otolith samples are aged[2].

Large numbers of eulachon (*Thaleichthys pacificus*) contaminated the acoustic returns from pollock in the Shelikof Strait area (see Results). The acoustic sign between these two species was apportioned using the catch weight of the two species in a manner as described by Guttormsen et al. (2001).

[2]At the time of completion of this report, only the otoliths collected during the Shelikof Strait area survey had been aged.

Relative estimation errors for the acoustic data were derived using a one-dimensional (1D) geostatistical method as described by Petitgas (1993), Williamson and Traynor (1996), and Rivoirard et al. (2000). Relative estimation error is defined as the ratio of the square root of the estimation variance to the estimate of "acoustic abundance". Geostatistical methods were used for computation of error because they consider the observed spatial structure. These errors quantify only transect sampling variability. Other sources of error (e.g., target strength, trawl sampling) are not included.

RESULTS AND DISCUSSION

Calibration

Acoustic system calibrations were conducted before, between, and after the two survey periods (Table 1). The EK500 38-kHz and 120-kHz collection systems showed no significant differences in gain parameters or transducer beam pattern characteristics before and after the Gulf of Alaska surveys. Calibration results from the EK60 acoustic system will be reported elsewhere.

Shumagin Islands

Biological Sampling

Biological data and specimens were collected in the Shumagin Islands from 8 AWT hauls and 2 bottom trawl hauls (Table 2, Fig. 1). Walleye pollock comprised 98.6% and 95.9% by weight of midwater and bottom trawl catches, respectively (Tables 3-4). Arrowtooth flounder (*Atheresthes stomias*) comprised about 2.1% by weight of the bottom trawl catch.

Distribution

Acoustic data were collected along 555 km (300 nmi) of transect tracklines in the Shumagin Islands. A distributional plot of acoustic backscattering attributed primarily to pollock indicated that the densest aggregations in the Shumagin Islands were distributed off Renshaw Point (Fig.

4), where the densest aggregations of pollock have been seen during previous Shumagin Island surveys. Adult[3] pollock were generally within 50 m of the sea floor, and juvenile pollock often formed well-defined schools at 100-150 m depth. The only substantial amounts of echosign detected outside of the Renshaw Point area were seen in Unga Strait and West Nagai Strait.

Length Composition

Trawl hauls conducted off Renshaw Point contained mostly adult pollock (Fig. 5A). Trawl hauls conducted in Unga Strait (Fig. 5B), West Nagai Strait (Fig. 5C), and Stepovak Bay (Fig. 5D) contained age-4 pollock, with lesser amounts of younger and adult pollock. The single trawl haul conducted in Shumagin Trough contained mostly age-2 and age-3 pollock (Fig. 5E). No age-1 pollock were caught in the Shumagin Islands during the 2003 survey.

Maturity

The unweighted maturity composition for males longer than 40 cm was 1% immature, 11% developing, 87% pre-spawning, 2% spawning, and 0% spent (Fig. 6A). The female maturity composition of fish longer than 40 cm was 3% immature, 13% developing, 73% pre-spawning, 2% spawning, and 9% spent. (Fig. 6B). A logistic model provided a reasonable fit to the female maturity at length data and predicted that 50% of females were mature at a length of 41 cm FL (Fig. 6C), which was similar to previous survey results -- 1995 (45 cm FL), 1996 (42 cm FL), 2001 (42 cm FL) and 2002 (44 cm FL). Average gonadosomatic index (GSI) for pre-spawning females was 0.15 (Fig. 6D).

Abundance

The pollock abundance estimate for the Shumagin Islands is 115 million pollock weighing 67,200 metric tons (t). The relative estimation error of the biomass based on the 1D analysis of echosign was 17.2%. Although higher than relative estimation errors for the Shelikof Strait surveys (3.6-6.9%), the 2003 estimate was lower than the 2002 estimate of 27.1%. Much of this

[3]Because age data are not yet available for the Shumagin Islands area survey, length ranges were used as a proxy for age based on length at age from previous surveys. Pollock between 9-16 cm FL are considered age 1, most pollock between 17-24 cm FL are considered age 2, most pollock from 25-30 cm FL are considered age 3, most pollock from 31-35 cm FL are considered age 4, and most pollock exceeding 35 cm FL are considered adults.

reduction in error can be attributed to a reduction in transect spacing design in the high density area off Renshaw Point from 3 to 1 nmi and running the transect pattern orthogonal to the bathymetry.

The abundance of pollock in the Shumagin Islands appears to have declined since the mid-1990s. The 2003 biomass is about one half of the 2002 estimate of 135,600 and about one-quarter of the 1995 estimate of 290,100 t (Fig. 7). Much of the decline in abundance between 2002 and 2003 can be attributed to lower densities of pollock in West Nagai Strait and off Renshaw Point. The echosign in West Nagai Strait, which accounted for 31% of the 2002 total, declined by 78% in 2003. The echosign off Renshaw Point, which accounted for 62% of the 2002 total, declined by 43% in 2003.

Inference about abundance trends is difficult to make for several reasons. Only the 1995 and 2001-03 surveys covered the entire Shumagin Islands area. Also, it is unknown whether changes in abundance reflect variation in the timing of peak spawning or an actual changes in the population. With the exception of the 1994 survey, which occurred in March well after peak spawning had occurred, the dates of the Shumagin Islands survey have been similar between years but the timing of peak spawning has not. For example, for the 2001 survey, 52% of the adult females were pre-spawning whereas 15% were spawning and 30% were spent, which suggested that peak had already occurred and that some fish might have already left the area. The Shumagin Islands surveys also may not provide predictions of future pollock abundance in the Gulf of Alaska. For example, over one-half of the adult pollock numbers in 2001 consisted of the 1993, 1994, and 1995 year classes; however, these year classes were detected in low numbers or were absent entirely as juveniles during the 1994, 1995, and 1996 surveys (Fig. 8).

Sanak Trough

Biological Sampling

Biological data and specimens were collected from 4 AWT hauls (Table 2, Fig. 1). Walleye pollock comprised 96.1% of the total catch (Table 5). Pacific cod (*Gadus macrocephalus*) was the next most abundant species caught (3.5% by weight).

Distribution

Acoustic data were collected along 119 km (64 nmi) of transect tracklines (Fig. 4). The densest aggregations were detected in the northern part of the trough, and over half of the echosign was observed on a single transect (Transect 6). Pollock were observed over bottom depths as shallow as 50 m and within 30 m of the surface.

Length Composition

Adult fish dominated catches in the northern portion of the trough. The single trawl haul conducted in the southern part of the trough contained a mixture of age-4 and adult pollock (Fig. 9)

Maturity

The unweighted maturity composition for males longer than 40 cm was 0% immature, 7% developing, 59% pre-spawning, 15% spawning, and 19% spent (Fig. 10A). The female maturity composition of fish longer than 40 cm was 2% immature, 15% developing, 52% pre-spawning, 3% spawning, and 27% spent (Fig. 10B). The high percentage of post-spawning fish suggests that the survey timing was late. A logistic model provided a reasonable fit to the female maturity at length data and predicted that 50% of females were mature at a length of 46 cm FL (Fig. 10C). The average GSI for pre-spawning females was 0.14 (Fig. 10D).

The abundance estimate for pollock is 83.7 million pollock weighing 80,500 t. The relative estimation error of the biomass based on the 1D analysis of echosign was 21.6%. This high relative estimate error suggests that future surveys use narrower transect spacing.

Sanak Trough was surveyed acoustically during February 2002, but because of an equipment failure, no trawl hauls were conducted. Dense echosign believed to be pollock was detected in much of the northern part of the trough, similar to the 2003 distribution.

Shelikof Strait

Biological Sampling

Biological data and specimens were collected in the Shelikof Strait from 17 AWT hauls and 2 bottom trawl hauls (Table 6, Fig. 2). Pollock and eulachon were the most abundant species by weight in midwater trawl hauls, comprising 82% and 16% of the total catch (Table 7). In the bottom trawls, several of which were conducted slightly off bottom or in midwater, pollock comprised 77% of the catch, with arrowtooth flounder (9%), smooth lumpsucker (*Aptocyclus ventricosus*, 6%), and longnose skate (*Raja rhina*, 5%) comprising most of the bycatch (Table 8).

Distribution

Acoustic data were collected along 1,451 km (784 nmi) of transect tracklines. Dense echosign attributed to near-bottom pollock was detected from about 30 nmi northwest of Chirikof Island to Katmai Bay (Fig. 11). Similar to the 2001 and 2002 surveys but unlike most other Shelikof Strait surveys, very little echosign was detected beyond Katmai Bay along the west side of the Strait, where the bulk of the mature pre-spawning pollock are usually found. Mid-water layers of sub-adult pollock, sometimes in the form of tight schools at about 175-200 m depth, were found on some transects (Fig. 12). This type of aggregation was more common during the day than during hours of darkness.

Length Composition

Pollock in the mid-water layer were predominantly 4 years old (Fig. 13A). No pollock exceeding 40 cm FL were caught in this layer. The majority of pollock in the near-bottom layer over most of the strait were also 4 years old, although the contribution of younger and older pollock was greater than in the mid-water layers (Fig. 13B). The few 1-year old pollock that

were observed in the survey area were caught in tows conducted either in the southernmost portion of the survey area (Fig. 13C) or along the north side of Kodiak Island (Fig. 13D).

Maturity

The unweighted maturity composition for males longer than 40 cm was 8% immature, 22% developing, 24% mature pre-spawning, 39% spawning, and 0% spent (Fig. 14A). The female maturity composition of fish longer than 40 cm was 10% immature, 42% developing, 46% pre-spawning, 0% spawning, and 2% spent (Fig. 14B). These results are similar to recent survey results in terms of low numbers of spawning and spent fish and is probably due to the relative decline in numbers of large fish in the survey area compared to earlier years. A logistic model provided a reasonable fit to the female maturity at length data and predicted that 50% of females were mature at a length of 44 cm FL (Fig. 14C), which is consistent with estimates since 1985 but larger than the 1983 and 1984 estimates of 37 and 38 cm FL. The average GSI for pre-spawning females of 0.11 (Fig. 14D) was similar to the mean GSI in 2002 (0.12) but lower than the mean GSIs (0.14-0.19) reported for other recent (1992-2001) Shelikof surveys.

Abundance

The abundance estimate is 1.061 billion pollock weighing 270,000 t. The estimates include adjustments for backscattering attributed by eulachon. The relative estimation error of the biomass based on the 1D analysis of echosign was 5.2%.

The trend in the size composition of pollock is consistent among surveys. The 1994 year class, which represented the largest estimate of 1-year old pollock (10.0 billion fish) in the history of the Shelikof Strait area EIT surveys and dominated Shelikof abundance estimates through 1998, has declined dramatically since 1998, accounting for only 1.3 million fish weighing 2,300 t in 2003 (Fig. 15). The 1999 year class (4.3 billion fish in 2000) was the second largest 1-year old estimate in survey history and has dominated abundance estimates, in both numbers and biomass, as 2-year old fish in 2001, 3-year old fish in 2002, and as 4-year old fish in 2003 (706 million fish weighing 192,500 t). The estimate of 1-year old pollock in 2003 of 45 million fish is one of the lowest estimates in survey history and suggests that the 2002 year class is weak.

The pollock biomass in Shelikof Strait declined dramatically in the 1980s, falling from 2,768,000 t in 1981 to 290,000 t in 1989 (Fig. 16). The biomass gradually rose in the 1990s, reaching 748,000 t in 1996. Since then, the population has declined, and although the 2003 biomass was 21% higher than 2002, the adult pollock (>40 cm FL) biomass of 32,000 t is the lowest in survey history.

Shelf break area near Chirikof Island

Biological Sampling

Biological data and specimens were collected near Chirikof Island from 7 AWT and 1 bottom trawl haul (Table 6). Four trawl hauls contained substantial amounts of pollock. Pollock (57%) and Pacific ocean perch (*Sebastes alutus*, 26%) comprised most of the catch in tows conducted near Chirikof Island (Table 9), and the single bottom trawl consisted of 99.8% Pacific ocean perch (Table 10).

Distribution

Acoustic data were collected along 415 km (224 nmi) of transect tracklines. Most echosign attributed to pollock occurred in diffuse mid-water layers between 300-500 m depth within the two shelf-break bights between Chirikof Island and Barnabas Trough over bottom depths of 300-800 m (Fig. 17). In both areas of the shelf break, substantial acoustic backscattering was attributed to myctophids and other micronekton species, which occurred along the offshore portions of the transects at about 200-300 m depth. This myctophid scattering layer, which occurred mostly over bottom depths from 800 to deeper than 1,500 m, may have obscured low densities of pollock.

Length Composition

The population size composition of pollock was bimodal, with a stronger mode around 50-57 cm FL and a weaker mode around 38-42 cm FL (Fig. 18A). No fish shorter than 35 cm FL were caught during the survey.

Maturity

The unweighted maturity composition for males longer than 40 cm was 1% immature, 4% developing, 74% mature pre-spawning, 21% spawning, and 0% spent (Fig. 19A). The female maturity composition of fish longer than 40 cm was 0% immature, 8% developing, 92% pre-spawning, 1% spawning, and 0% spent (Fig. 19B). The dominance of pre-spawning fish suggested that the survey timing was appropriate. A logistic model provided a reasonable fit to the female maturity at length data and predicted that 50% of females were mature at a length of 44 cm FL (Fig. 19C). The average GSI for pre-spawning females was 0.15 (Fig. 19D).

Abundance

The abundance estimate is 29 million pollock weighing 30,900 t. The relative estimation error of the biomass based on the 1D analysis of echosign was 20.7%. The biomass in 2003 was 62% lower than the 82,100 t estimated in the same area in 2002, which was the only other formal survey of this area.

Shelf break area near Middleton Island

Biological Sampling

Near Middleton Island, biological data and specimens were collected from 5 AWT hauls (Table 6, Fig. 3). Three of these trawl hauls caught mostly pollock. Overall, the tows caught mostly pollock (82%). Rougheye (*Sebastes aleutianus*, 7%) and shortraker rockfish (*Sebastes borealis*, 5%) were the predominant bycatch species caught (Table 11). A tow conducted in Yakutat Canyon, which was not used in the analysis of the shelf break area, consisted mostly of shortraker rockfish (55%) and pollock (37%; Table 12).

Distribution

Acoustic data were collected along 243 km (131 nmi) of transect tracklines. The small amounts of pollock detected both east and west of Middleton Island occurred at similar water column and bottom depths to those observed in the Chirikof Island survey area (Fig. 20).

Length Composition

The population size composition of pollock based on the single haul conducted west of Middleton Island was bimodal, with a strong mode at 39-46 cm and a weaker mode between 49-54 cm FL (Fig. 18B). The size distribution east of the island, based on 2 hauls, was largely unimodal, with most of the fish exceeding 50 cm FL (Fig. 18C).

Maturity

The unweighted maturity composition for males longer than 40 cm was 0% immature, 3% developing, 44% mature pre-spawning, 52% spawning, and 0% spent (Fig. 21A). The female maturity composition of fish longer than 40 cm was 0% immature, 5% developing, 95% pre-spawning, 0% spawning, and 1% spent (Fig. 21B). The dominance of pre-spawning female fish suggested that the survey timing was appropriate. A logistic model provided a reasonable fit to the female maturity at length data and predicted that 50% of females were mature at a length of 44 cm FL (Fig. 21C). The average GSI for pre-spawning females was 0.14 (Fig. 21D).

Abundance

The abundance estimate is 7 million pollock weighing 6,000 t. The relative estimation error of the biomass based on the 1D analysis of echosign was 25.6%.

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Table 1. Results from acoustic system calibrations associated with the winter/early spring 2003 echo integration-trawl surveys of walleye pollock in the Gulf of Alaska.

Date	Location	Frequency (kHz)	Water temp (°C)		Sphere range from transducer (m)	TS gain (dB)	s_V gain (dB)	3-dB Beam width (deg)		Angle offset (deg)	
			At transducer[1]	At sphere				Along	Athwart	Along	Athwart
6-Feb	Alitak Bay, AK	38	3.0	3.0	25.5	25.9	26.8	--	--	--	--
		120	3.0	3.0	20.0	25.8	27.0	--	--	--	--
8-Mar	Captains Bay, AK	38	4.6	4.9	36.3	25.8	26.7	6.98	6.87	-0.10	-0.02
		120	4.6	4.9	27.5	25.5	26.8	6.85	6.68	-0.24	0.11
30-Mar	Sea Otter Bay, AK	38	5.4	5.4	33.3	25.8	26.7	6.96	6.85	-0.11	-0.01
		120	5.4	5.4	23.1	25.5	26.7	6.85	6.81	-0.24	0.07
	System settings during surveys	38	-	-	-	25.9	25.6	6.90	6.80	-0.08	0.03
		120	-	-	-	26.5	26.7	6.80	6.80	-0.06	0.07

[1]The transducer was located approximately 9 m below the water surface.

Note: Gain and beam pattern terms are defined in the "Operator Manual for Simrad EK500 Scientific Echo Sounder (1993)" available from Simrad Subsea A/S , Strandpromenaden 50, P.O. Box 111, N-3191 Horten, Norway.

Table 2. Trawl station summary from the winter 2003 echo integration-trawl survey, MF2003-01, of walleye pollock in the Shumagin Islands area (hauls 1-10) and Sanak Trough (hauls 11-14).

Haul	Gear[1]		Time	Duration	Start Position				Depth (m)		Temp (deg. C)		Profiler[3]	Pollock catch		Other catch	
No.	Type	Date	(GMT)	(min)	Latitude (N)		Longitude (W)		Gear[2]	Bottom	Gear	Surface	No.	kg	number	catch (kg)	(kg)
1	AWT	7 Feb	18:18	2	55	13.17	159	3.44	174	197	6.1	5.5	301	11,238	2,105	18	91
2	AWT	8 Feb	11:28	37	55	40.62	159	49.98	120	124	5.6	5.1	302	1,614	721	283	30
3	AWT	8 Feb	23:30	1	55	34.65	160	13.91	125	187	5.5	5.3	303	2,889	2,080	0	0
4	PNE	9 Feb	1:14	5	55	35.04	160	16.69	192	192	5.7	5.3	304	1,717	1,617	259	93
5	PNE	9 Feb	3:12	2	55	33.41	160	11.33	182	182	5.6	5.3	305	1,152	1,850	49	57
6	AWT	9 Feb	6:01	2	55	35.35	160	9.62	130	166	5.6	5.3	306	1,939	1,580	4	5
7	AWT	9 Feb	8:39	2	55	34.49	160	19.54	152	184	5.6	5.3	307	646	221	106	23
8	AWT	9 Feb	11:21	5	55	29.97	160	21.50	128	134	5.5	5.1	308	1,664	743	19	2
9	AWT	9 Feb	15:23	5	55	27.84	160	32.76	111	134	5.5	5.1	309	3,269	1,344	13	6
10	AWT	9 Feb	23:51	10	55	6.45	160	21.98	165	201	5.6	5.3	310	10,584	2,906	3	14
11	AWT	10 Feb	13:12	29	54	32.88	162	40.16	124	140	5.3	5.2	311	134	77	51	26
12	AWT	10 Feb	16:53	4	54	41.49	162	33.28	79	111	5.3	5.0	312	163	152	14	82
13	AWT	10 Feb	18:45	2	54	44.06	162	37.55	53	96	5.1	4.9	313	1,216	1,250	5	1
14	AWT	10 Feb	21:52	2	54	41.03	162	36.97	98	134	5.3	5.1	314	1,946	2,028	6	32

[1]AWT = Aleutian wing midwater trawl and PNE = poly nor-eastern bottom trawl

[2]Gear temperature was measured at the trawl headrope depth.

[3]301-314 = SeaBird SBE39

Table 3. Summary of catch by species in midwater trawls conducted during the 2003 pollock echo integration-trawl survey of the Shumagin Islands area.

Common name	Scientific name	Weight (kg)	Percent	Numbers	Percent
Walleye pollock	*Theragra chalcogramma*	11,700.4	98.6%	33,843	98.7%
Salmon shark	*Lamna ditropis*	90.0	0.8%	1	<0.1%
Pacific cod	*Gadus macrocephalus*	44.4	0.4%	7	<0.1%
Eulachon	*Thaleichthys pacificus*	12.2	0.1%	369	1.1%
Jellyfish unident.	Scyphozoa	9.8	0.1%	20	0.1%
Arrowtooth flounder	*Atheresthes stomias*	6.1	0.1%	9	<0.1%
Chinook salmon	*Oncorhynchus tshawytscha*	4.3	<0.1%	2	<0.1%
Flathead sole	*Hippoglossoides elassodon*	4.0	<0.1%	13	<0.1%
Shrimp unident.	Decapoda	0.1	<0.1%	24	0.1%
Sturgeon poacher	*Podothecus acipenserinus*	<0.1	<0.1%	1	<0.1%
Total		11,871.2		34,288	

Table 4. Summary of catch by species in bottom trawls conducted during the 2003 pollock echo integration-trawl survey of the Shumagin Islands area.

Common name	Scientific name	Weight (kg)	Percent	Numbers	Percent
Walleye pollock	*Theragra chalcogramma*	3,467.6	95.9%	2,869	90.5%
Arrowtooth flounder	*Atheresthes stomias*	75.2	2.1%	85	2.7%
Pacific cod	*Gadus macrocephalus*	35.0	1.0%	5	0.2%
Flathead sole	*Hippoglossoides elassodon*	22.5	0.6%	49	1.5%
Eulachon	*Thaleichthys pacificus*	6.4	0.2%	145	4.6%
Smooth lumpsucker	*Aptocyclus ventricosus*	4.0	0.1%	2	0.1%
Rex sole	*Glyptocephalus zachirus*	3.5	0.1%	14	0.4%
Pacific halibut	*Hippoglossus stenolepis*	1.8	<0.1%	1	<0.1%
Rock sole	*Lepidopsetta sp.*	1.4	<0.1%	4	0.1%
Jellyfish unident.	Scyphozoa	1.3	<0.1%	3	0.1%
Total		3,614.2		3,169	

Table 5. Summary of catch by species in the midwater trawl conducted during the 2003 pollock echo integration-trawl survey of Sanak Trough.

Common name	Scientific name	Weight (kg)	Percent	Numbers	Percent
Walleye pollock	*Theragra chalcogramma*	3,507.7	96.1%	3,459	97.9%
Pacific cod	*Gadus macrocephalus*	126.5	3.5%	12	0.3%
Jellyfish unident.	Scyphozoa	10.5	0.3%	18	0.5%
Chinook salmon	*Oncorhynchus tshawytscha*	2.1	0.1%	1	<0.1%
Arrowtooth flounder	*Atheresthes stomias*	1.2	<0.1%	4	0.1%
Rock sole	*Lepidopsetta sp.*	0.3	<0.1%	1	<0.1%
Capelin	*Mallotus villosus*	0.1	<0.1%	28	0.8%
Eulachon	*Thaleichthys pacificus*	0.1	<0.1%	9	0.3%
Shrimp unident.	Decapoda	<0.1	<0.1%	1	<0.1%
Total		3,648.6		3,533	

Table 6. Trawl station summary from the winter 2003 echo integration-trawl survey, MF2003-05, of walleye pollock in Shelikof Strait (hauls 1-19), near Chirikof Island (hauls 20-27), near Middleton Island (hauls 28-32), and in Yakutat Canyon (haul 33).

Haul	Gear[1]		Time	Duration	Start Position				Depth (m)		Temp (deg. C)		Profiler[3]	Pollock catch		Other catch	
No.	Type	Date	(GMT)	(min)	Latitude (N)		Longitude (W)		Gear[2]	Bottom	Gear	Surface	No.	kg	number	(kg)	(kg)
1	AWT	17 Mar	8:31	34	55	49.40	156	20.62	236	247	5.7	4.9	301	127	1,485	83	3,804
2	PNE	17 Mar	17:57	21	56	4.18	156	15.73	208	214	5.4	5.2	302	59	205	54	212
3	AWT	18 Mar	2:59	18	56	12.38	156	5.88	228	236	5.6	5.3	303	681	3,317	75	1,667
4	AWT	18 Mar	8:42	30	56	26.51	156	7.91	258	273	5.8	4.8	304	269	936	20	436
5	AWT	18 Mar	18:12	5	56	39.41	155	57.15	259	288	5.5	5.1	305	2,316	9,679	34	832
6	AWT	18 Mar	21:03	5	56	37.88	155	49.20	244	259	5.1	5.1	306	701	2,687	122	2,854
7	AWT	18 Mar	23:28	20	56	39.04	155	53.08	215	279	5.6	4.9	307	616	2,453	34	1,597
8	AWT	19 Mar	12:35	3	56	50.69	155	53.11	227	305	5.6	5.0	308	250	1,043	22	662
9	AWT	19 Mar	14:19	5	56	52.92	155	45.50	227	292	5.6	-	309	1,301	6,805	69	1,494
10	AWT	19 Mar	18:51	10	57	2.29	155	55.58	192	237	6.0	5.0	310	1,358	5,835	2	13
11	AWT	20 Mar	3:10	25	57	5.49	155	22.93	244	258	5.3	5.0	311	2,546	8,530	1,046	3,079
12	PNE	20 Mar	14:31	8	57	20.98	155	20.64	223	254	5.4	5.0	312	187	694	21	115
13	AWT	20 Mar	21:38	4	57	26.59	154	53.63	157	215	6.1	5.0	313	5,189	24,598	11	257
14	AWT	21 Mar	2:10	15	57	34.95	155	18.44	260	301	5.7	5.4	314	1,415	5,144	683	8,059
15	AWT	21 Mar	10:09	12	57	43.55	154	53.62	228	248	5.7	4.8	315	1,194	4,575	146	1,197
16	AWT	21 Mar	14:27	5	57	51.13	154	47.90	240	281	5.8	4.4	316	1,159	2,915	271	2,340
17	AWT	21 Mar	22:55	40	57	52.92	154	5.30	186	200	5.9	5.6	317	1,006	3,358	664	15,576
18	AWT	22 Mar	5:37	30	58	4.37	153	50.13	188	195	5.9	5.6	318	660	2,092	822	7,572
19	AWT	22 Mar	13:41	11	58	11.28	153	21.03	202	219	5.8	5.5	319	468	2,278	445	7,782
20	AWT	25 Mar	22:04	25	55	42.39	154	59.90	341	443	4.8	5.8	320	114	98	1	20
21	AWT	26 Mar	9:41	10	56	0.10	154	29.10	338	516	4.9	5.4	321	90	96	3	82
22	AWT	26 Mar	17:05	30	55	52.95	153	49.17	340	611	5.4	5.4	322	-	-	252	383
23	AWT	26 Mar	20:41	35	55	55.51	153	35.29	391	448	4.6	6.1	323	169	159	43	558
24	AWT	27 Mar	5:39	30	56	16.51	153	7.08	331	496	5.1	5.7	324	181	156	59	799
25	AWT	27 Mar	10:34	20	56	18.63	152	35.98	307	1336	5.5	5.5	325	-	-	6	850
26	AWT	27 Mar	14:57	11	56	32.14	152	33.37	181	204	5.8	5.1	326	-	-	61	9
27	PNE	27 Mar	16:32	15	56	32.13	152	33.29	194	216	5.5	5.8	327	-	-	2,640	4,443
28	AWT	28 Mar	22:39	25	59	14.25	146	54.03	342	466	4.8	6.4	328	349	591	137	1,287
29	AWT	29 Mar	9:39	17	59	29.16	145	50.80	324	420	5.7	5.7	329	12	7	65	651
30	AWT	29 Mar	13:55	40	59	28.15	145	34.02	351	422	5.0	6.3	330	1,328	970	202	78
31	AWT	29 Mar	23:44	40	59	31.58	145	48.08	364	614	5.0	6.1	331	956	766	158	2,563
32	AWT	30 Mar	2:44	30	59	26.18	145	25.27	294	505	5.6	4.6	332	-	-	3	127
33	AWT	31 Mar	11:48	50	59	27.28	141	11.82	303	326	5.5	6.3	333	365	407	619	1,258

[1]AWT = Aleutian wing midwater trawl and PNE = poly nor-eastern bottom trawl

[2]Gear temperature was measured at the trawl headrope depth.

[3]301-333 = SeaBird SBE39

Table 7. Summary of catch by species in midwater trawls conducted during the 2003 pollock echo integration-trawl survey of the Shelikof Strait area.

Common name	Scientific name	Weight (kg)	Percent	Numbers	Percent
Walleye pollock	*Theragra chalcogramma*	21,256.6	82.4%	87,730	59.7%
Eulachon	*Thaleichthys pacificus*	4,120.4	16.0%	57,264	39.0%
Pacific sleeper shark	*Somniosus pacificus*	180.6	0.7%	4	<0.1%
Chinook salmon	*Oncorhynchus tshawytscha*	37.8	0.1%	59	<0.1%
Squid unident.	Teuthoidea (order)	37.6	0.1%	659	0.4%
Arrowtooth flounder	*Atheresthes stomias*	37.3	0.1%	119	0.1%
Smooth lumpsucker	*Aptocyclus ventricosus*	37.2	0.1%	28	<0.1%
Chinook salmon	*Oncorhynchus tshawytscha*	29.4	0.1%	21	<0.1%
Pacific cod	*Gadus macrocephalus*	21.4	0.1%	10	<0.1%
Rougheye rockfish	*Sebastes aleutianus*	18.7	0.1%	6	<0.1%
Flathead sole	*Hippoglossoides elassodon*	11.7	<0.1%	45	<0.1%
Shrimp unident.	Decapoda (order)	5.8	<0.1%	896	0.6%
Jellyfish unident.	Scyphozoa (class)	5.3	<0.1%	17	<0.1%
Majestic squid	*Berryteuthis magister*	2.3	<0.1%	3	<0.1%
Rock sole sp.	*Lepidopsetta bilineata*	1.5	<0.1%	3	<0.1%
Northern smoothtongue	*Leuroglossus schmidti*	0.6	<0.1%	30	<0.1%
Yellow Irish lord	*Hemilepidotus jordani*	0.4	<0.1%	3	<0.1%
Longnose poacher	*Sarritor frenatus*	0.1	<0.1%	3	<0.1%
Fish unident.		0.1	<0.1%	47	<0.1%
Capelin	*Mallotus villosus*	<0.1	<0.1%	4	<0.1%
Total		25,804.7		146,951	

Table 8. Summary of catch by species in bottom trawls conducted during the 2003 pollock echo integration-trawl survey of the Shelikof Strait area.

Common name	Scientific name	Weight (kg)	Percent	Numbers	Percent
Walleye pollock	*Theragra chalcogramma*	245.8	76.5%	899	73.3%
Arrowtooth flounder	*Atheresthes stomias*	27.9	8.7%	26	2.1%
Smooth lumpsucker	*Aptocyclus ventricosus*	19.8	6.2%	14	1.1%
Longnose skate	*Raja rhina*	17.3	5.4%	1	0.1%
Eulachon	*Thaleichthys pacificus*	7.3	2.3%	207	16.9%
Pacific cod	*Gadus macrocephalus*	2.2	0.7%	1	0.1%
Squid unident.	Teuthoidea (order)	0.8	0.2%	8	0.7%
Jellyfish unident.	Scyphozoa (class)	0.4	0.1%	3	0.2%
Shrimp unident.	Decapoda (order)	<0.1	<0.1%	67	5.5%
Total		321.4		1,226	

Table 9. Summary of catch by species in midwater trawls conducted during the 2003 pollock echo integration-trawl survey of the Gulf of Alaska shelf break near Chirikof Island.

Common name	Scientific name	Weight (kg)	Percent	Numbers	Percent
Walleye pollock	*Theragra chalcogramma*	554.5	56.6%	509	15.9%
Pacific ocean perch	*Sebastes alutus*	250.8	25.6%	359	11.2%
Giant grenadier	*Albatrossia pectoralis*	42.6	4.3%	13	0.4%
Shortraker rockfish	*Sebastes borealis*	38.6	3.9%	11	0.3%
Pacific cod	*Gadus macrocephalus*	23.9	2.4%	1	<0.1%
Chinook salmon	*Oncorhynchus tshawytscha*	20.0	2.0%	6	0.2%
Arrowtooth flounder	*Atheresthes stomias*	17.1	1.7%	2	0.1%
Eulachon	*Thaleichthys pacificus*	14.1	1.4%	247	7.7%
Myctophidae	Myctophidae	8.6	0.9%	1,474	45.9%
Rougheye rockfish	*Sebastes aleutianus*	5.8	0.6%	3	0.1%
Jellyfish unident.	Scyphozoa (class)	1.4	0.1%	7	0.2%
Glass shrimp	*Archaeomysis grebnitzkii*	0.7	0.1%	405	12.6%
Northern smoothtongue	*Leuroglossus schmidti*	0.5	0.1%	28	0.9%
Majestic squid	Berryteuthis magister	0.5	<0.1%	4	0.1%
Squid unident.	Teuthoidea (order)	0.3	<0.1%	61	1.9%
Salps unident.	Thaliacea	0.2	<0.1%	3	0.1%
Mytilidae	Mytilidae	0.1	<0.1%	11	0.3%
Diaphus theta	*Diaphus theta*	0.0	<0.1%	7	0.2%
Fish unident.		0.0	<0.1%	1	<0.1%
Shrimp unident.	Decapoda (order)	0.0	<0.1%	55	1.7%
Argentinidae	Argentinidae	0.0	<0.1%	1	<0.1%
Shining loosejaw	*Aristostomias scintillans*	0.0	<0.1%	1	<0.1%
Viperfish unident.	Chauliodontidae	0.0	<0.1%	1	<0.1%
Total		979.6		3,210	

Table 10. Summary of catch by species in the bottom trawl conducted during the 2003 pollock echo integration-trawl survey of the the Gulf of Alaska shelf break near Chirikof Island.

Common name	Scientific name	Weight (kg)	Percent	Numbers	Percent
Pacific ocean perch	*Sebastes alutus*	2,633.5	99.8%	4,440	99.9%
Shortraker rockfish	*Sebastes borealis*	3.8	0.1%	1	<0.1%
Arrowtooth flounder	*Atheresthes stomias*	1.6	0.1%	1	<0.1%
Dusky rockfish	*Sebastes ciliatus*	1.2	<0.1%	1	<0.1%
Total		2,640.0		4,443	

Table 11. Summary of catch by species in midwater trawls conducted during the 2003 pollock echo integration-trawl survey of the the Gulf of Alaska shelf break near Middleton Island.

Common name	Scientific name	Weight (kg)	Percent	Numbers	Percent
Walleye pollock	*Theragra chalcogramma*	2,645.2	82.4%	2,334	33.2%
Rougheye rockfish	*Sebastes aleutianus*	207.2	6.5%	106	1.5%
Shortraker rockfish	*Sebastes borealis*	174.1	5.4%	28	0.4%
Giant grenadier	*Albatrossia pectoralis*	71.2	2.2%	24	0.3%
Pacific ocean perch	*Sebastes alutus*	34.4	1.1%	45	0.6%
Arrowtooth flounder	*Atheresthes stomias*	30.7	1.0%	38	0.5%
Myctophidae	Myctophidae	17.6	0.5%	2,981	42.3%
Majestic squid	*Berryteuthis magister*	15.4	0.5%	31	0.4%
Chum salmon	*Oncorhynchus nerka*	4.9	0.2%	2	<0.1%
Eulachon	*Thaleichthys pacificus*	4.0	0.1%	54	0.8%
Jellyfish unident.	Scyphozoa (class)	2.9	0.1%	16	0.2%
Glass shrimp	*Archaeomysis grebnitzkii*	1.8	0.1%	1,280	18.2%
Squid unident.	Teuthoidea	0.4	<0.1%	58	0.8%
Diaphus theta	*Diaphus theta*	0.1	<0.1%	7	0.1%
Northern smoothtongue	*Leuroglossus schmidti*	0.0	<0.1%	4	0.1%
Pacific lamprey	*Lampetra tridentata*	0.0	<0.1%	2	<0.1%
Shrimp unident.	Decapoda (order)	0.0	<0.1%	28	0.4%
Pacific viperfish	*Chauliodus macouni*	0.0	<0.1%	2	<0.1%
Total		3,209.9		7,040	

Table 12. Summary of catch by species in the midwater trawls conducted during the 2003 pollock echo integration-trawl survey of Yakutat Canyon.

Common name	Scientific name	Weight (kg)	Percent	Numbers	Percent
Shortraker rockfish	*Sebastes borealis*	544.2	55.3%	95	5.7%
Walleye pollock	*Theragra chalcogramma*	365.3	37.1%	407	24.4%
Eulachon	*Thaleichthys pacificus*	33.8	3.4%	727	43.7%
Rougheye rockfish	*Sebastes aleutianus*	17.0	1.7%	16	1.0%
Spiny dogfish	*Squalus acanthias*	16.7	1.7%	5	0.3%
Chinook salmon	*Oncorhynchus tshawytscha*	6.1	0.6%	2	0.1%
Myctophidae	Myctophidae	0.6	0.1%	129	7.7%
Pasiphaea pacifica	*Pasiphaea pacifica*	0.5	<0.1%	274	16.5%
Majestic squid	*Berryteuthis magister*	0.2	<0.1%	9	0.5%
Jellyfish unident.	Scyphozoa (class)	0.1	<0.1%	1	0.1%
Total		984.5		1,665	

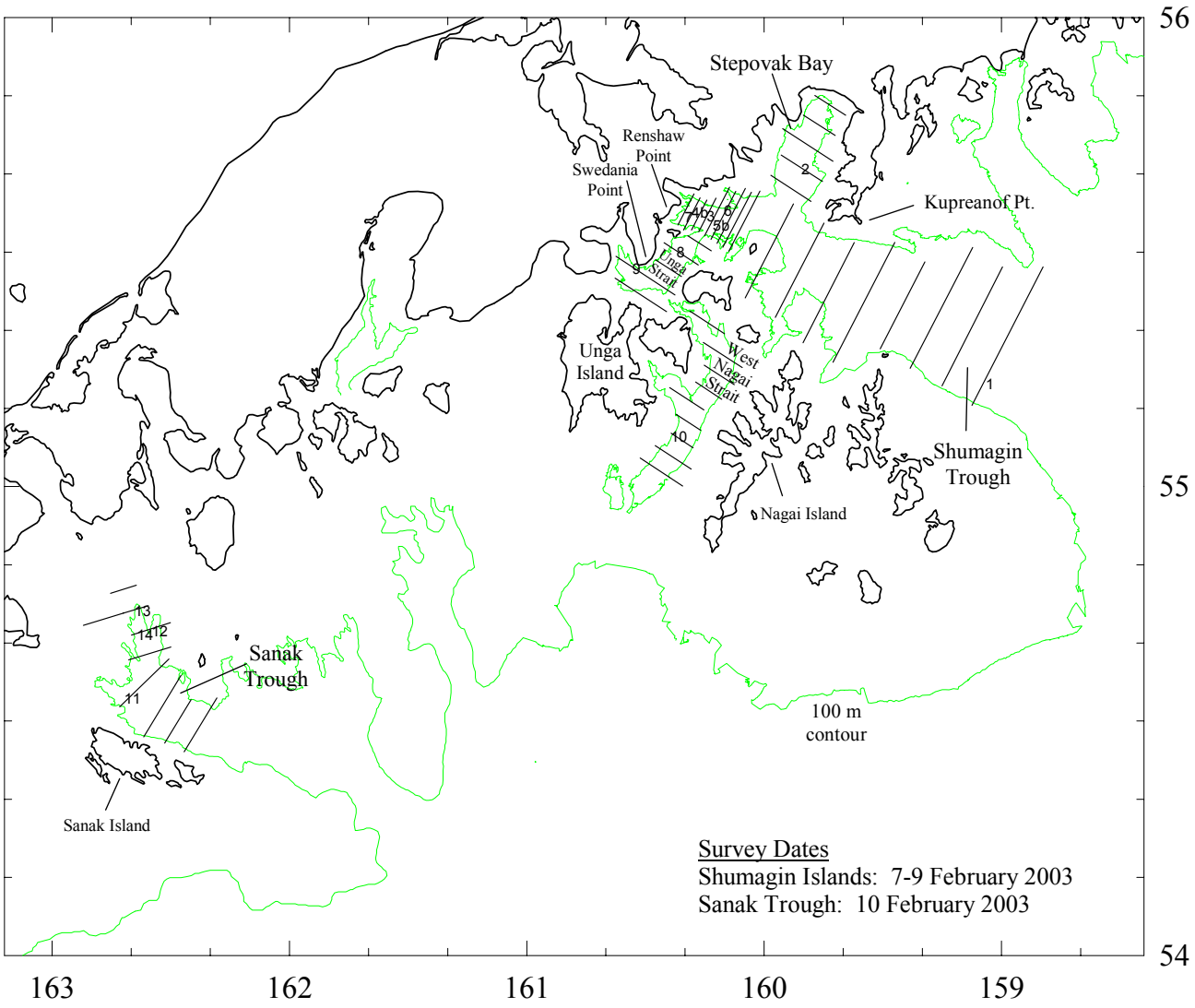

Figure 1. Survey trackline and location of hauls conducted during the 2003 echo integration-trawl surveys of the Shumagin Islands and Sanak Trough. Numbers followed by a "b" represent hauls made with the bottom trawl and all other numbers represent hauls made with the midwater trawl.

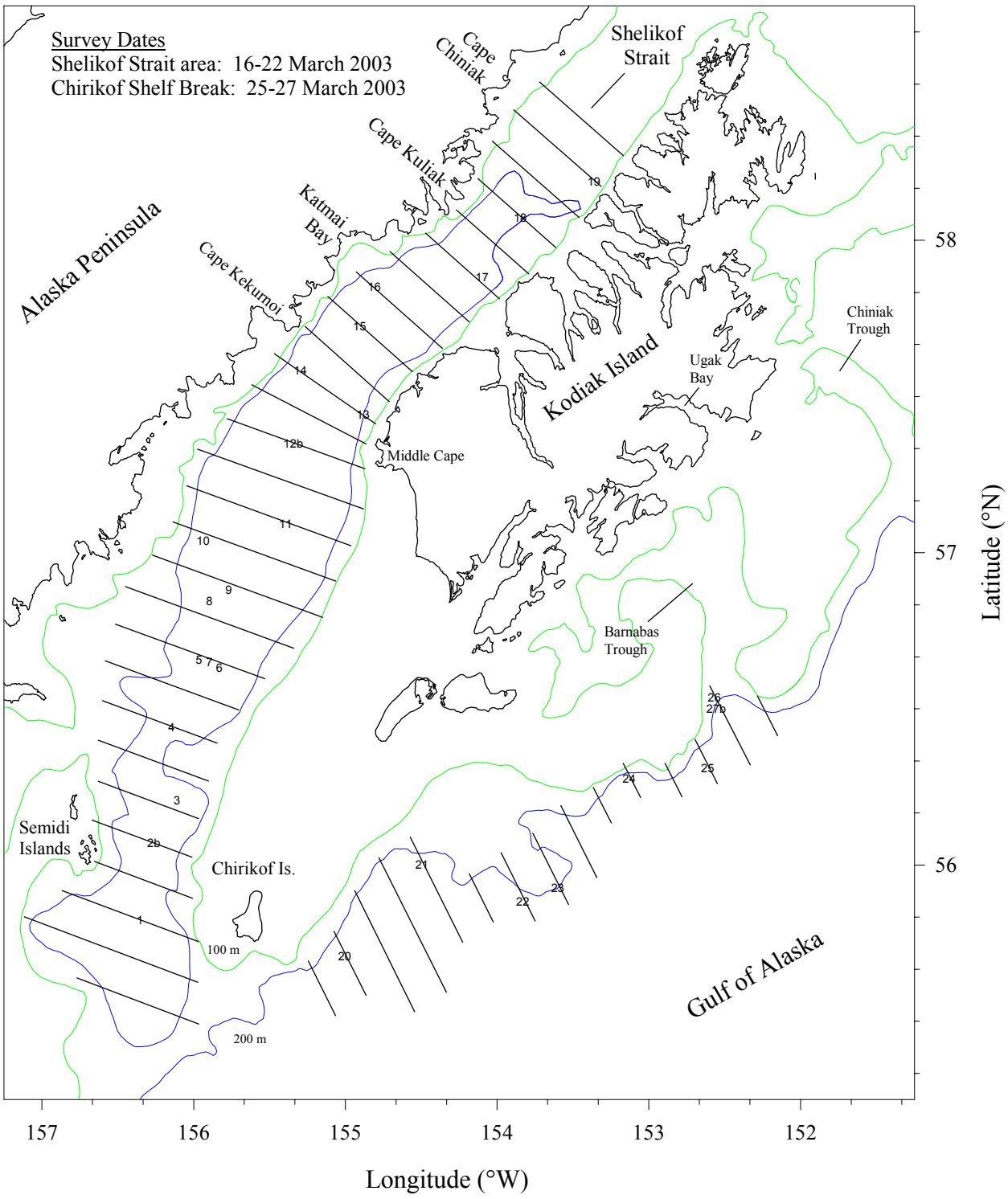

Figure 2. Transect lines and locations of midwater (circle) and bottom (triangle) trawl hauls conducted during the winter 2003 echo integration-trawl survey of the Shelikof Strait area and the Gulf of Alaska shelf break near Chirikof Island.

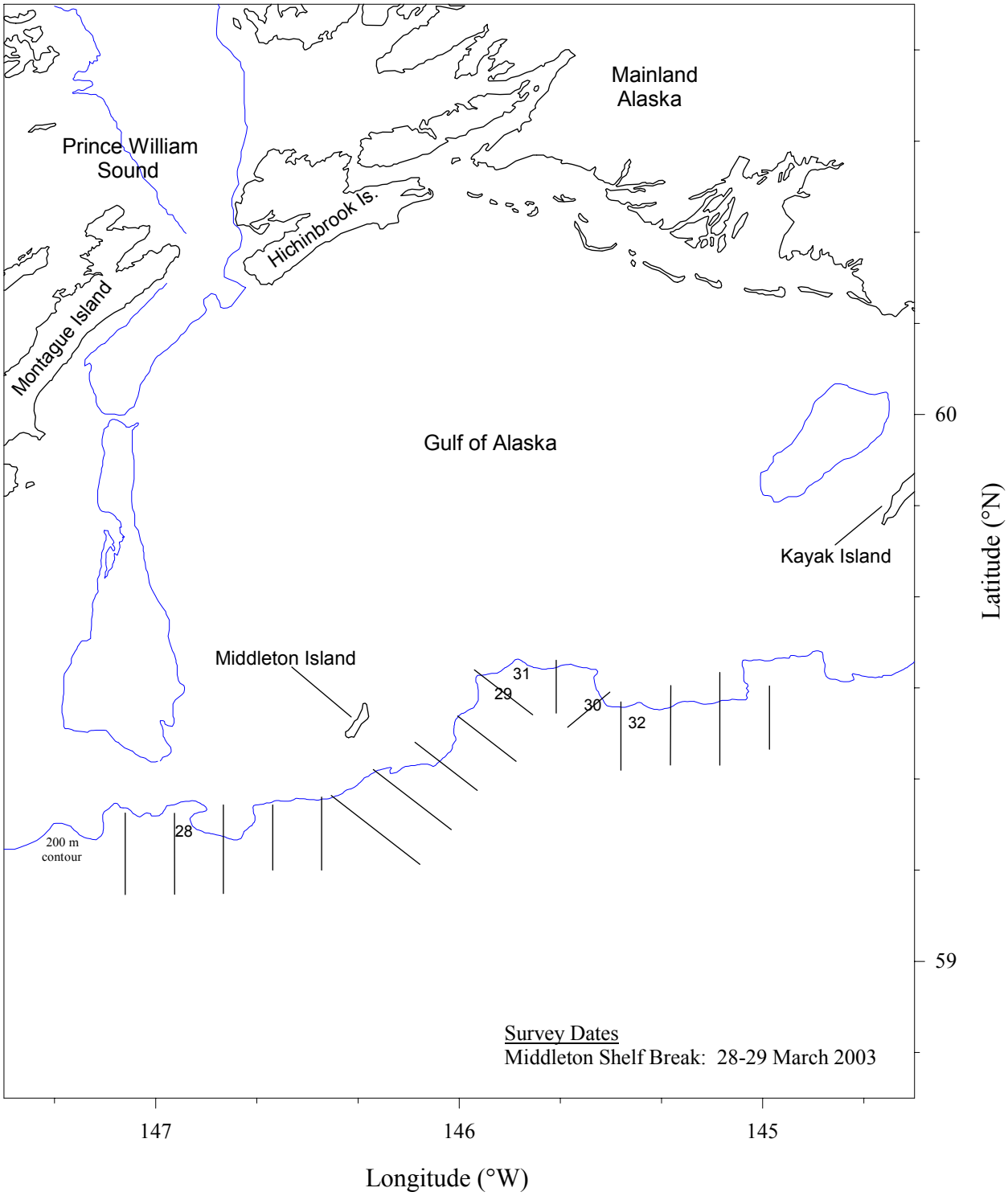

Figure 3. Transect lines and locations of midwater (circle) trawl hauls conducted during the winter 2003 echo integration-trawl survey of the Gulf of Alaska shelf break near Middleton Island.

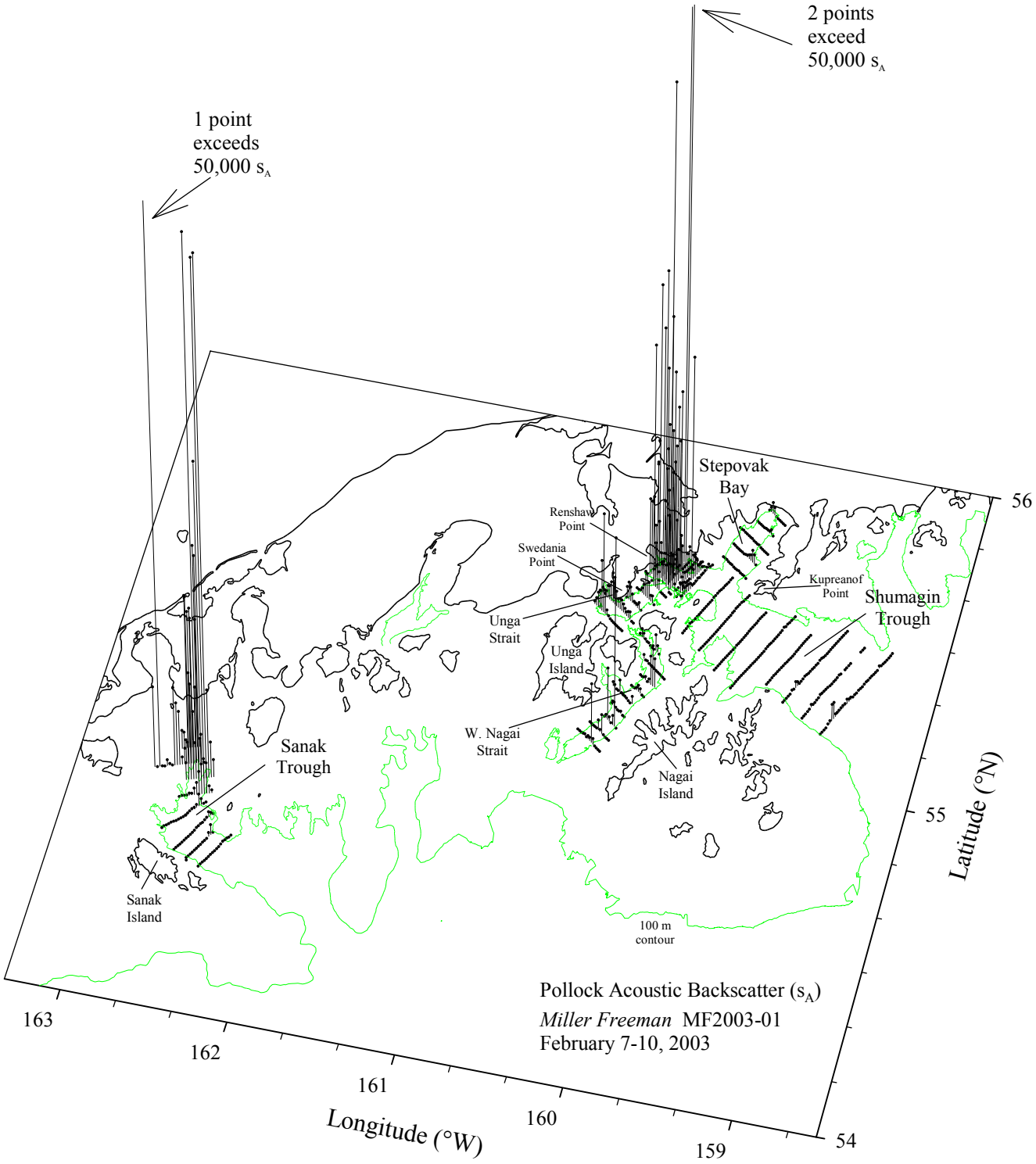

Figure 4. Relative backscattering (s_A) attributed primarily to pollock along tracklines during the winter 2003 echo integration-trawl surveys of the Shumagin Islands and Sanak Trough in the Gulf of Alaska.

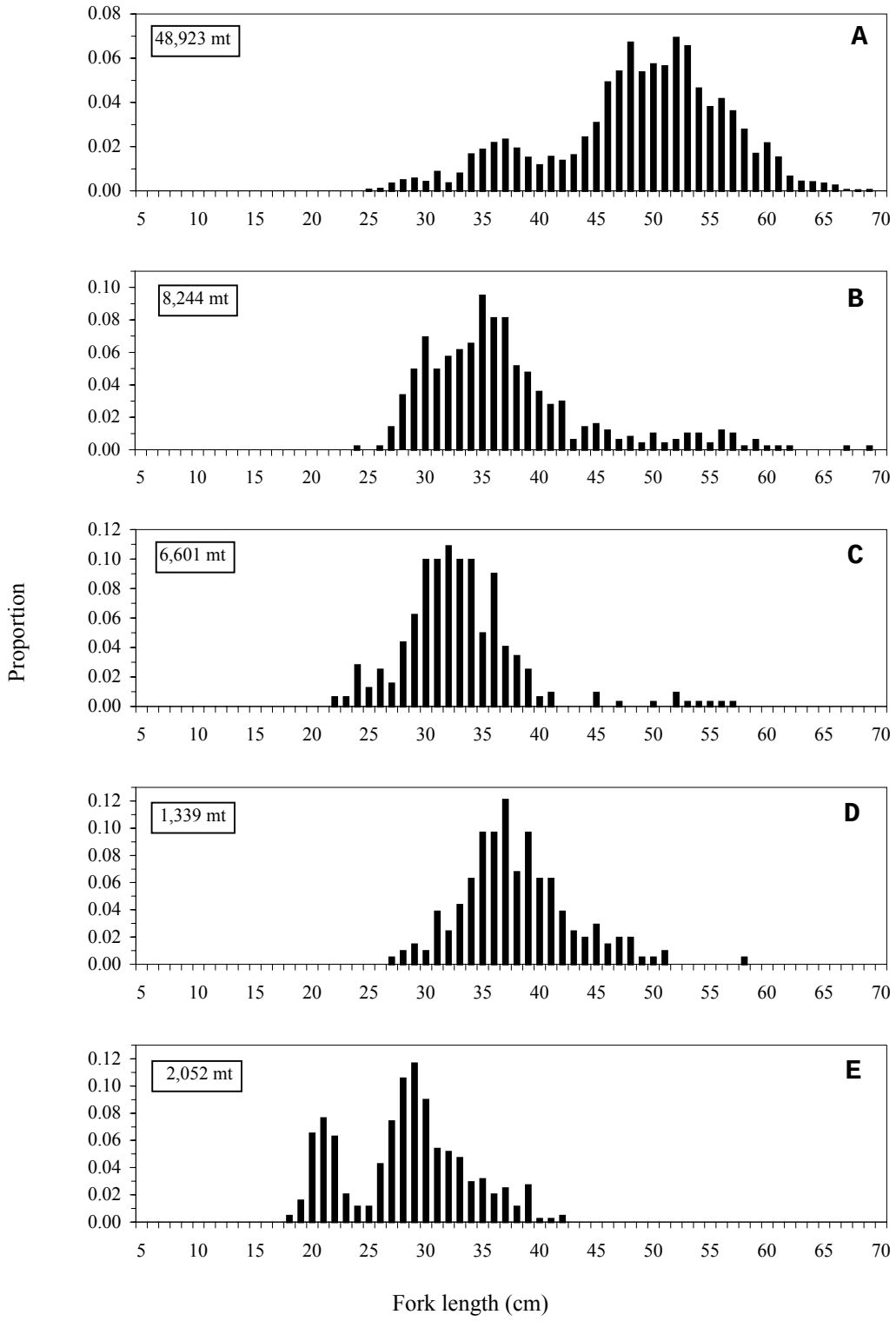

Figure 5. The size distribution of pollock (by proportion of fish) (A) off Renshaw Point, (B) in Unga Strait, (C) in West Nagai Strait, (D) in Stepovak Bay, and (E) in Shumagin Trough for the 2003 echo integration-trawl survey of the Shumagin Islands.

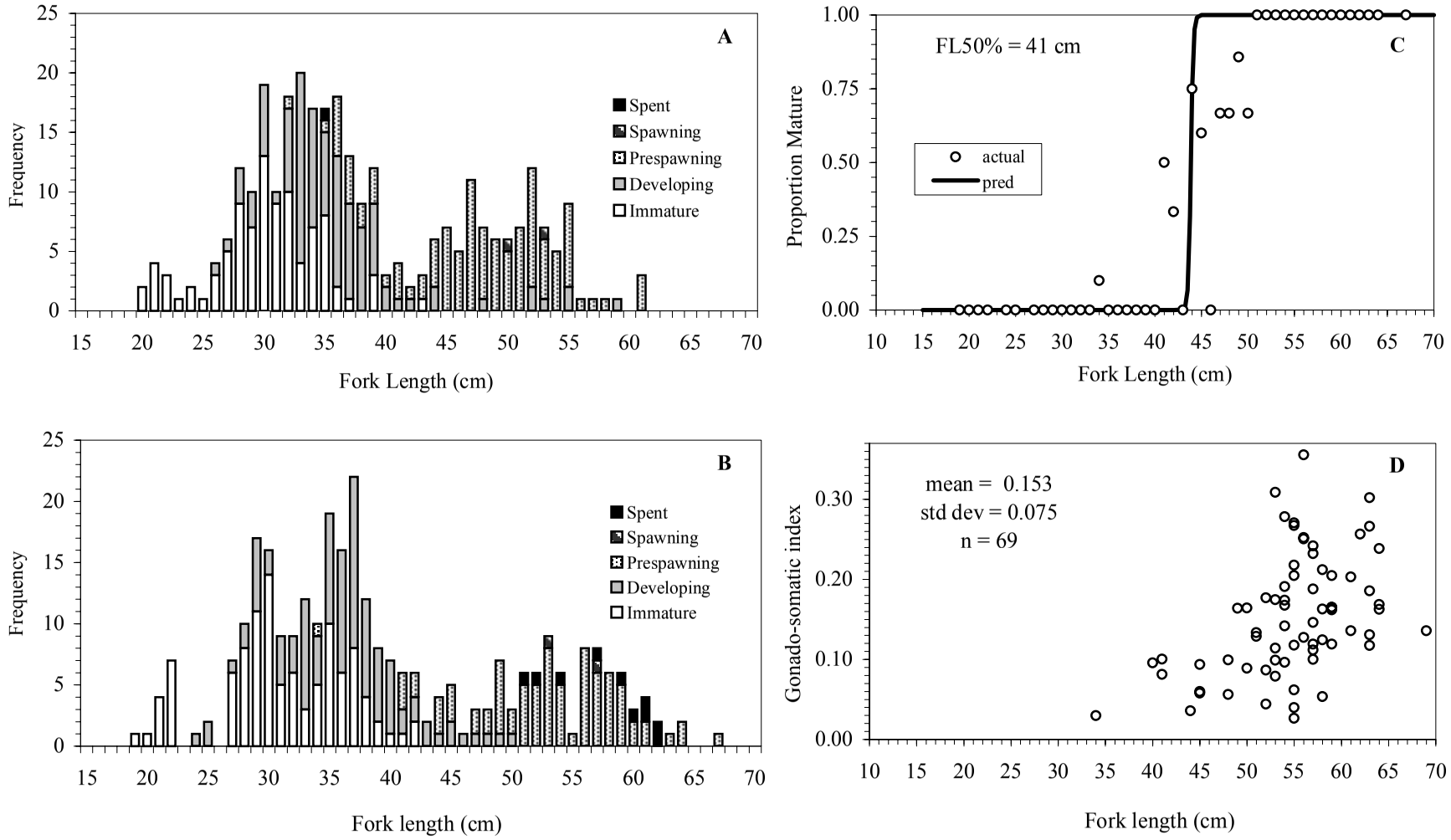

Figure 6. Maturity stages for (A) male and (B) female pollock, (C) fitted logistic function and proportion mature by 1-cm size class for female pollock. and (D) average gonadosomatic index for pre-spawning females examined during the winter 2003 echo integraton-trawl survey of the Shumagin Islands area of the Gulf of Alaska.

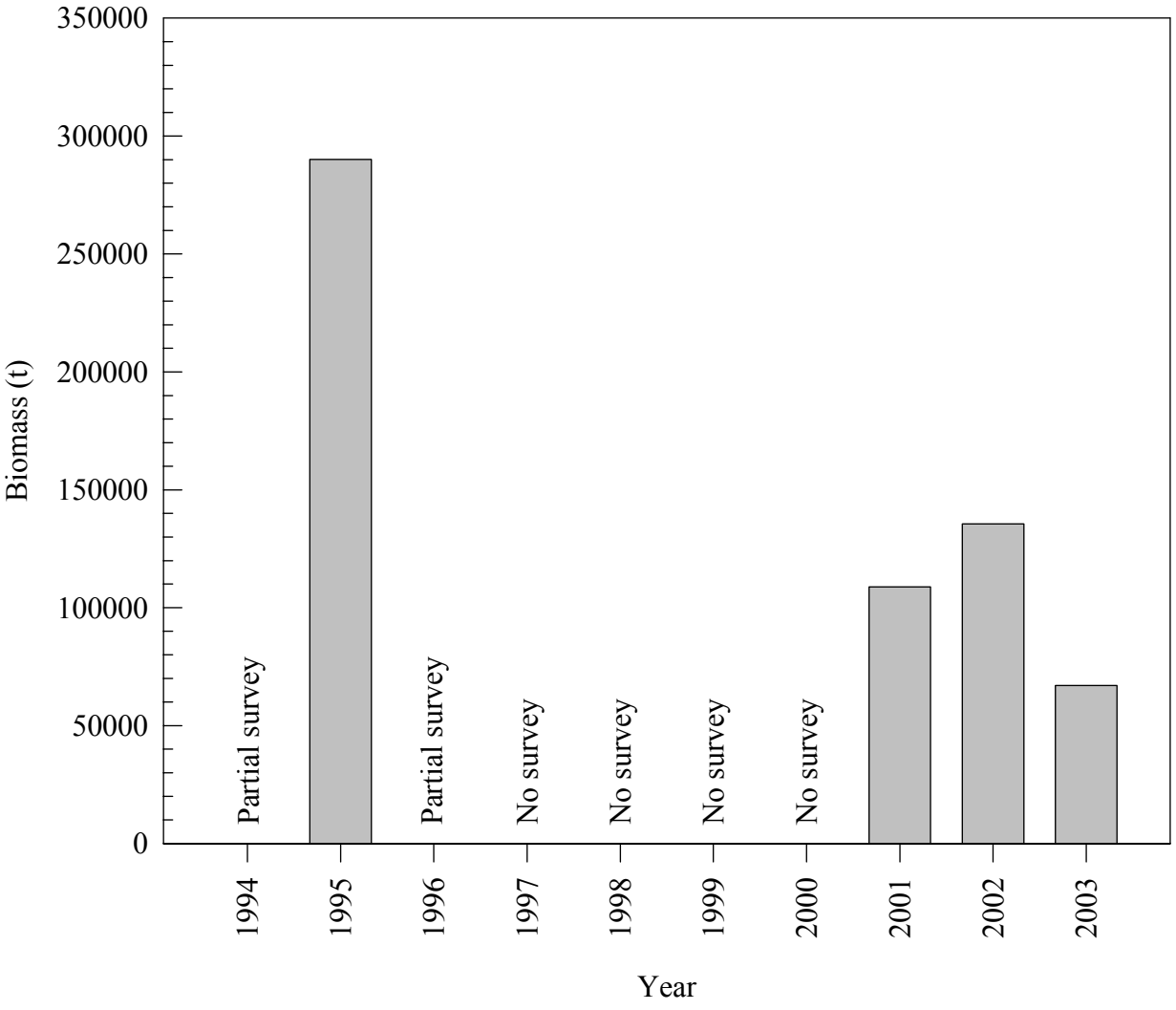

Figure 7. Summary of annual pollock biomass estimates based on echo integration-trawl surveys of the Shumagin Islands.

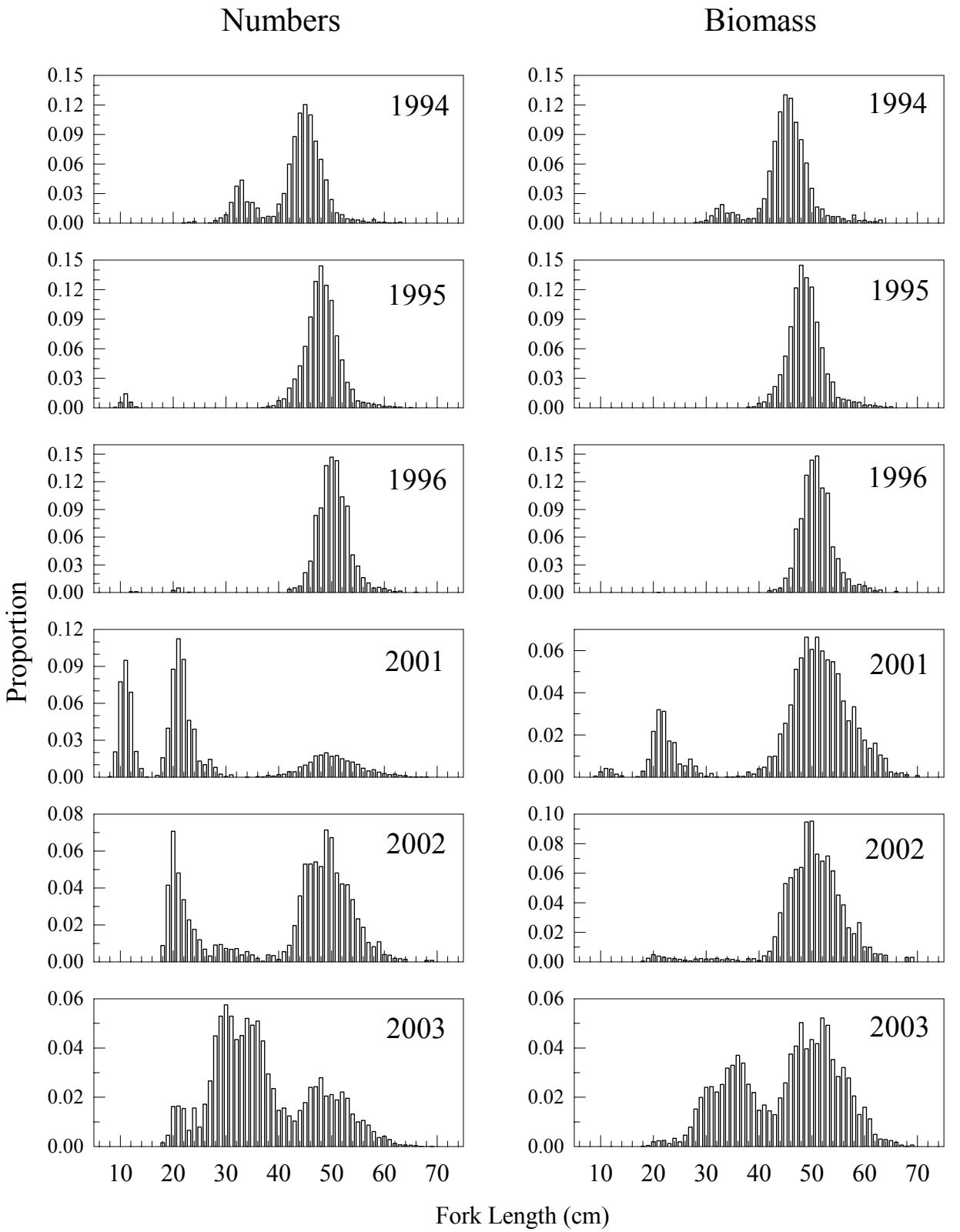

Figure 8. Pollock size composition estimates for the Shumagin Islands area based on echo integration-trawl surveys during 1994-96 and 2001-03.

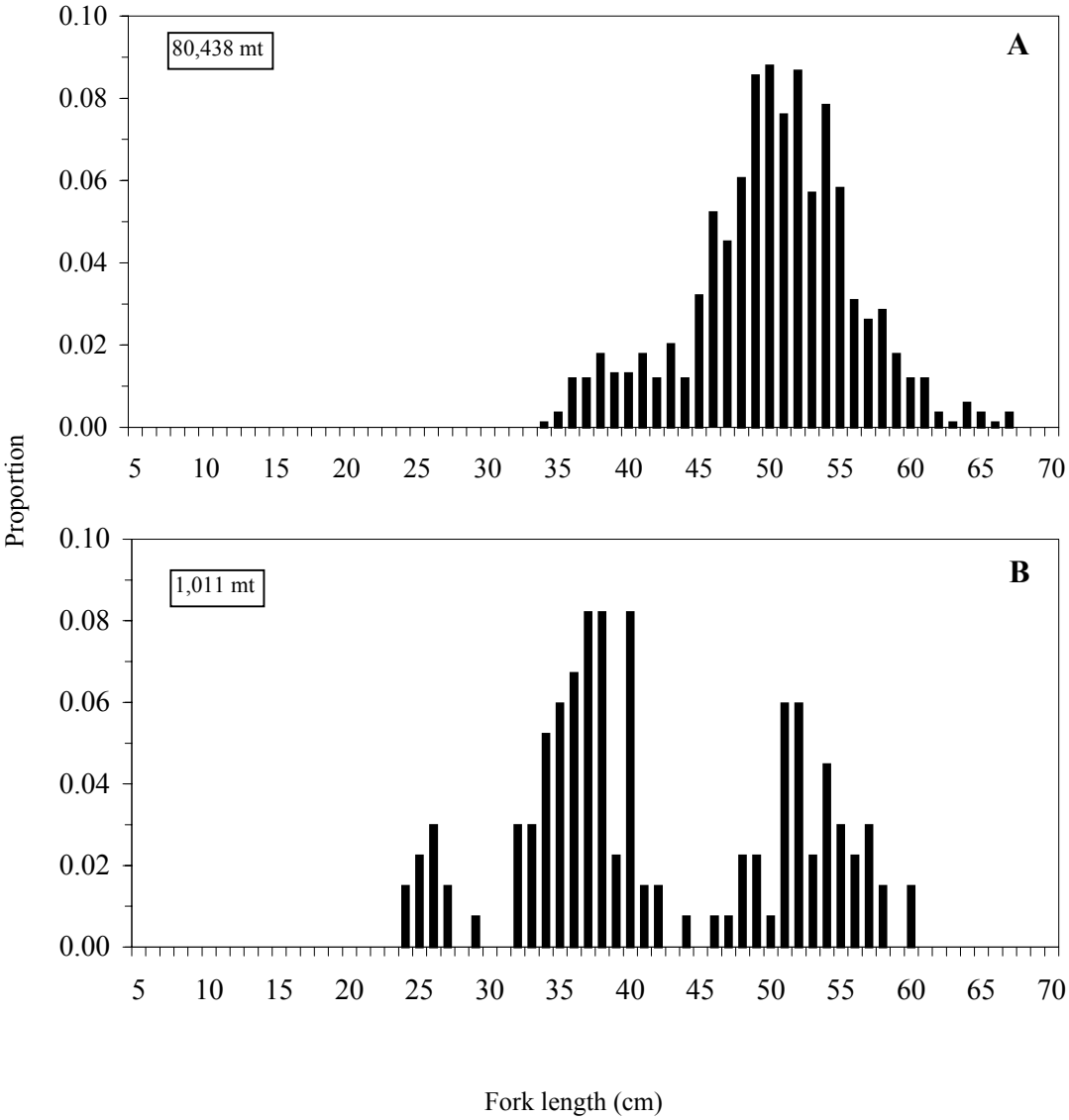

Figure 9. The size distribution of pollock (by proportion of fish) of (A) northern Sanak Trough and (B) southern Sanak Trough for the 2003 echo integration-trawl survey of Sanak Trough.

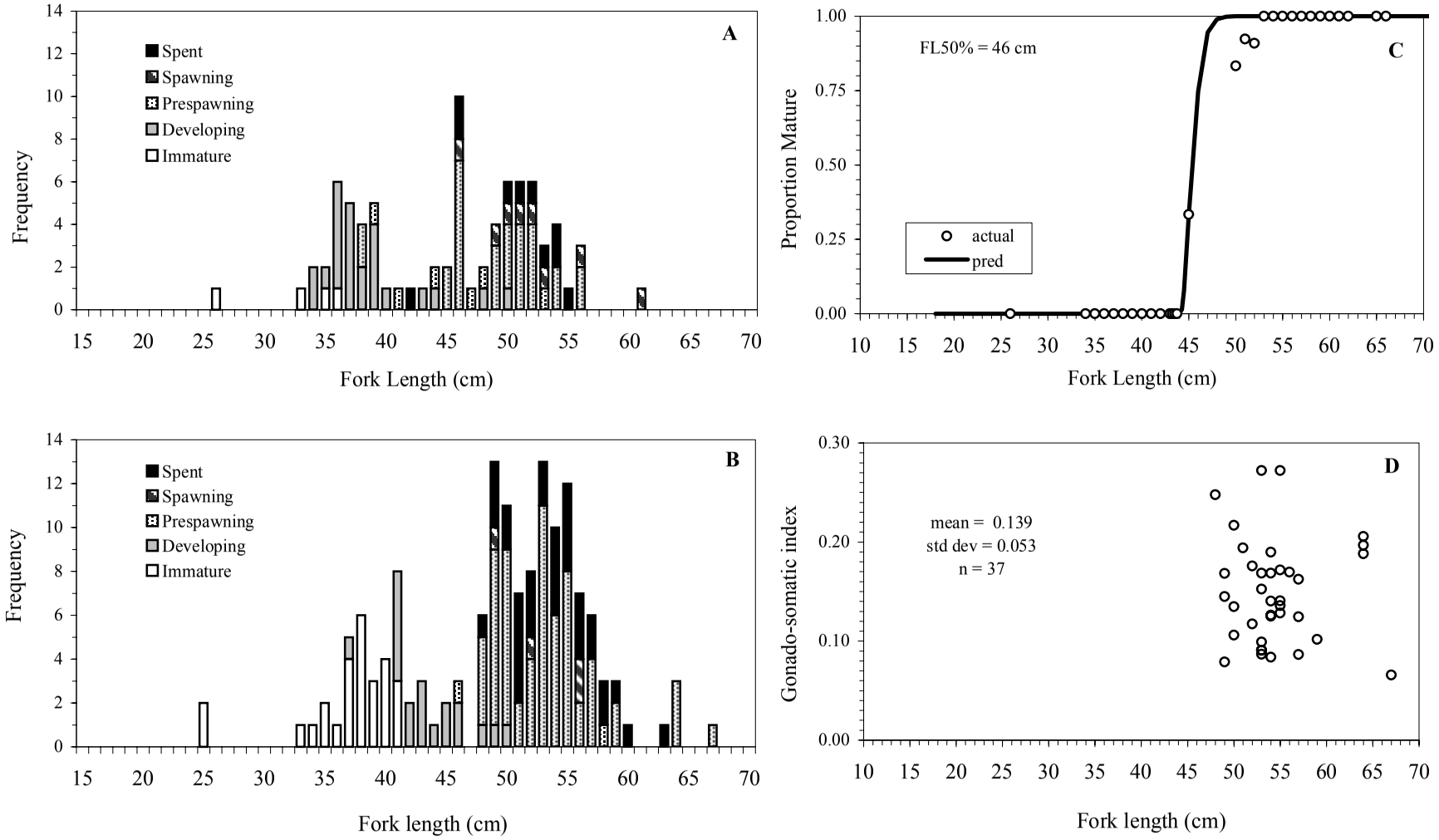

Figure 10. Maturity stages for (A) male and (B) female pollock, (C) fitted logistic function and proportion mature by 1-cm size class for female pollock. and (D) average gonadosomatic index for pre-spawning females examined during the winter 2003 echo integraton-trawl survey of Sanak Trough in the Gulf of Alaska.

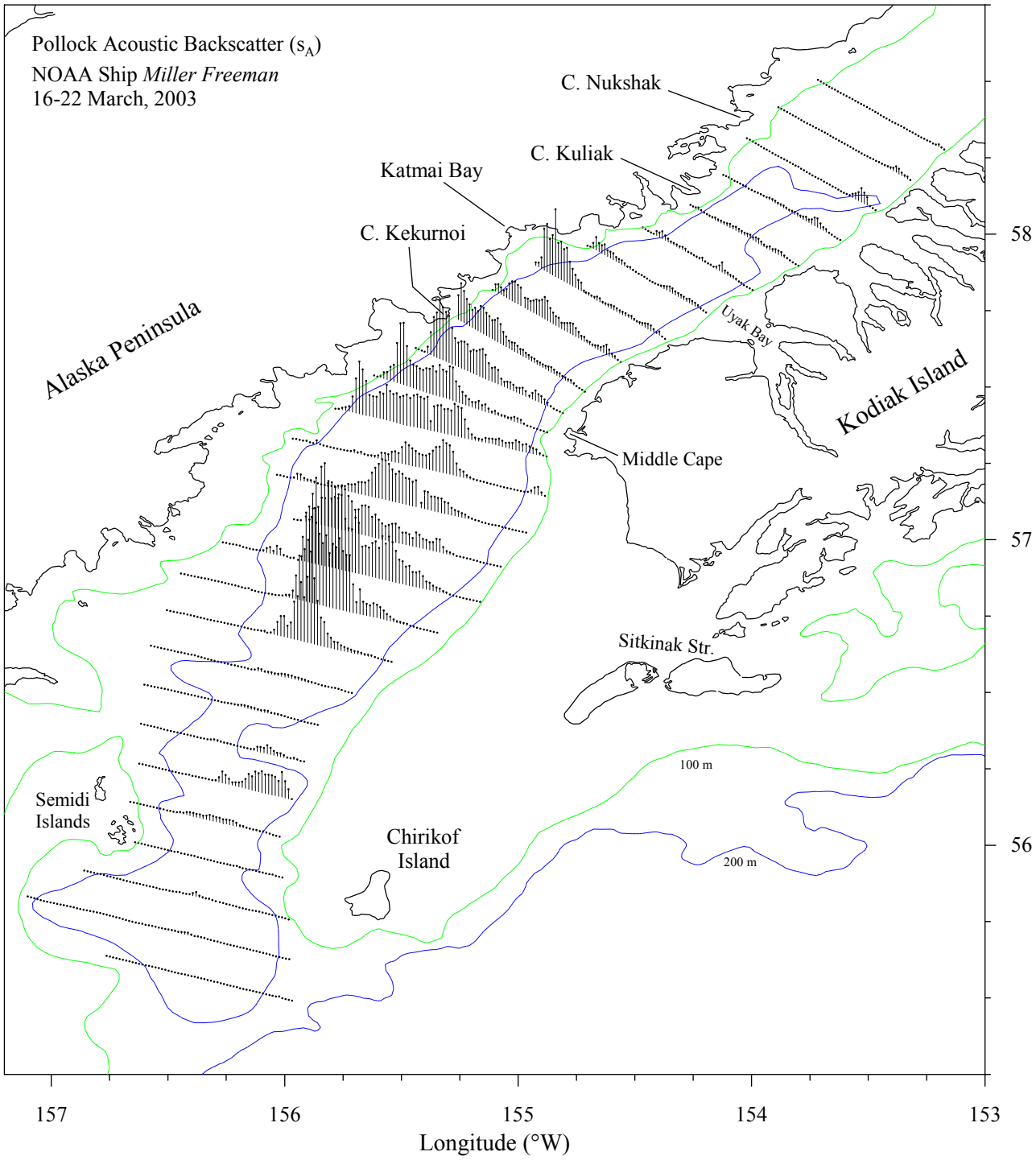

Figure 11. Relative pollock backscatter (s_A) attributed to near-bottom layers along transects from the 2003 winter echo integration-trawl survey of the Shelikof Strait area.

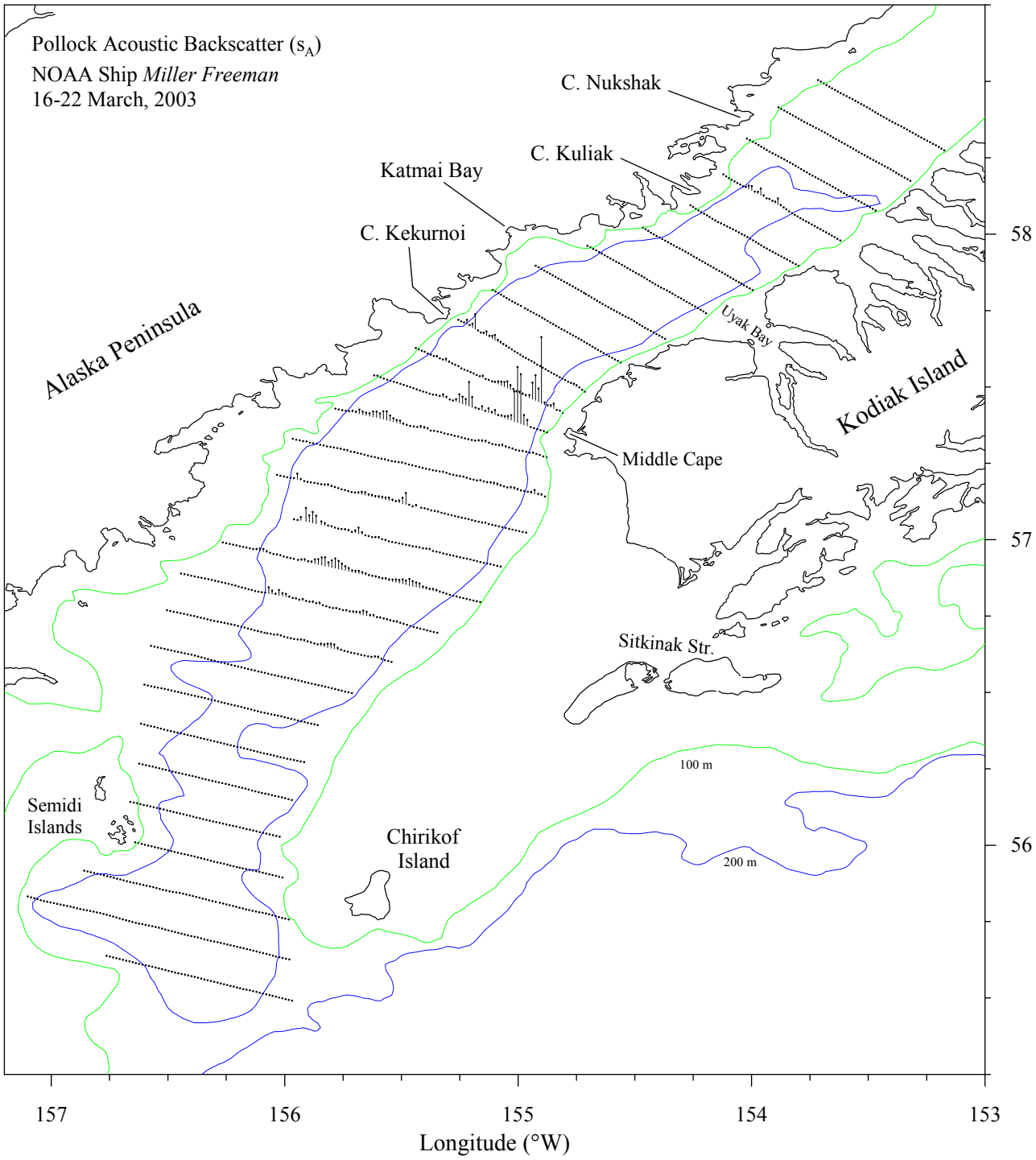

Figure 12. Relative pollock backscatter (s_A) attributed to mid-water layers (primarily subadult pollock) along transects from the 2003 winter echo integration-trawl survey of the Shelikof Strait area.

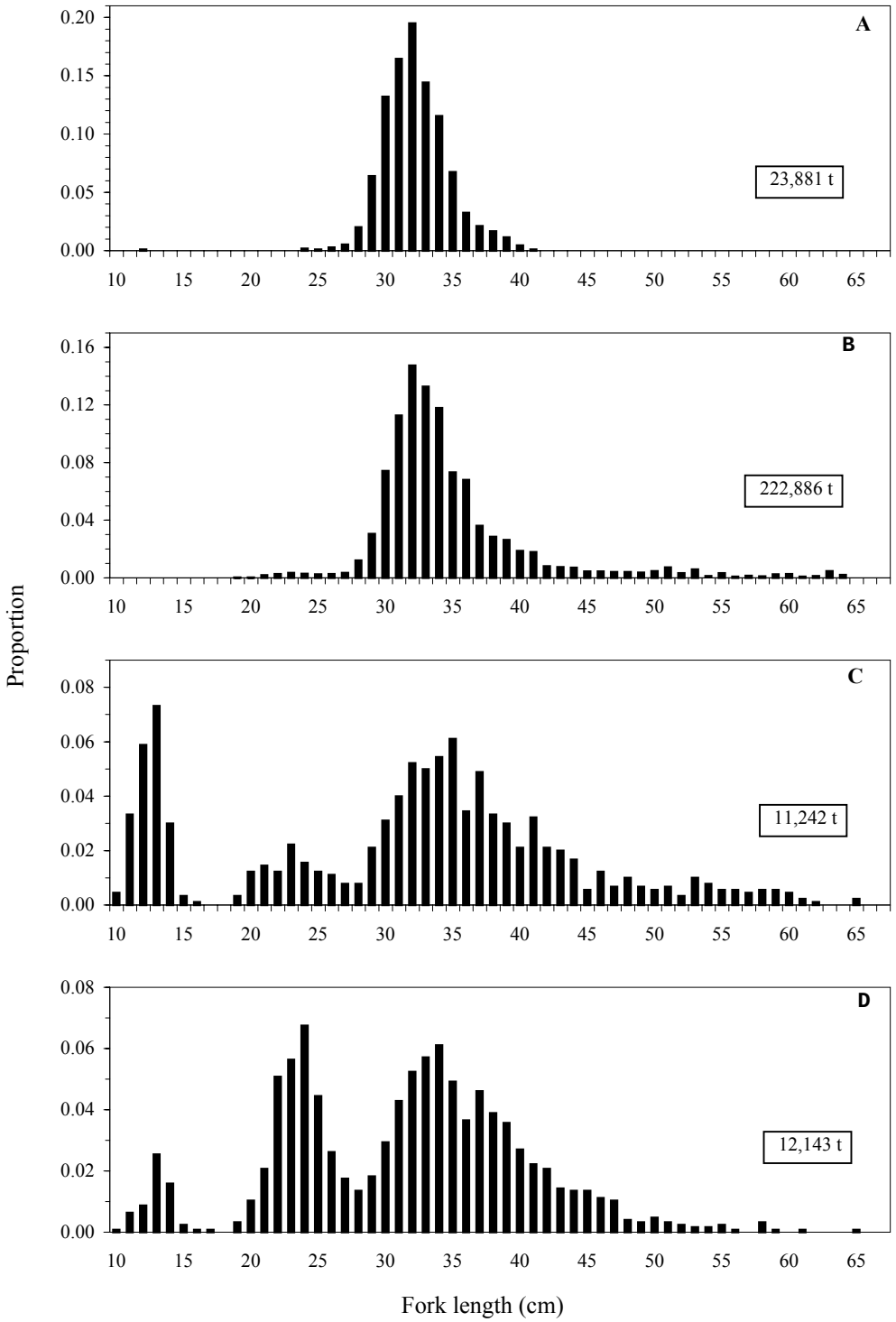

Figure 13. Estimates of pollock size distribution (numbers of fish) and biomass (metric tons (t)) for (A) mid-water layers and near-bottom layers (B) from 30 nm northwest of Chirikof Island to Katmai Bay, (C) east of the Semidi Islands, and (D) along the north side of Kodiak Island for the 2003 echo integration-trawl survey of Shelikof Strait.

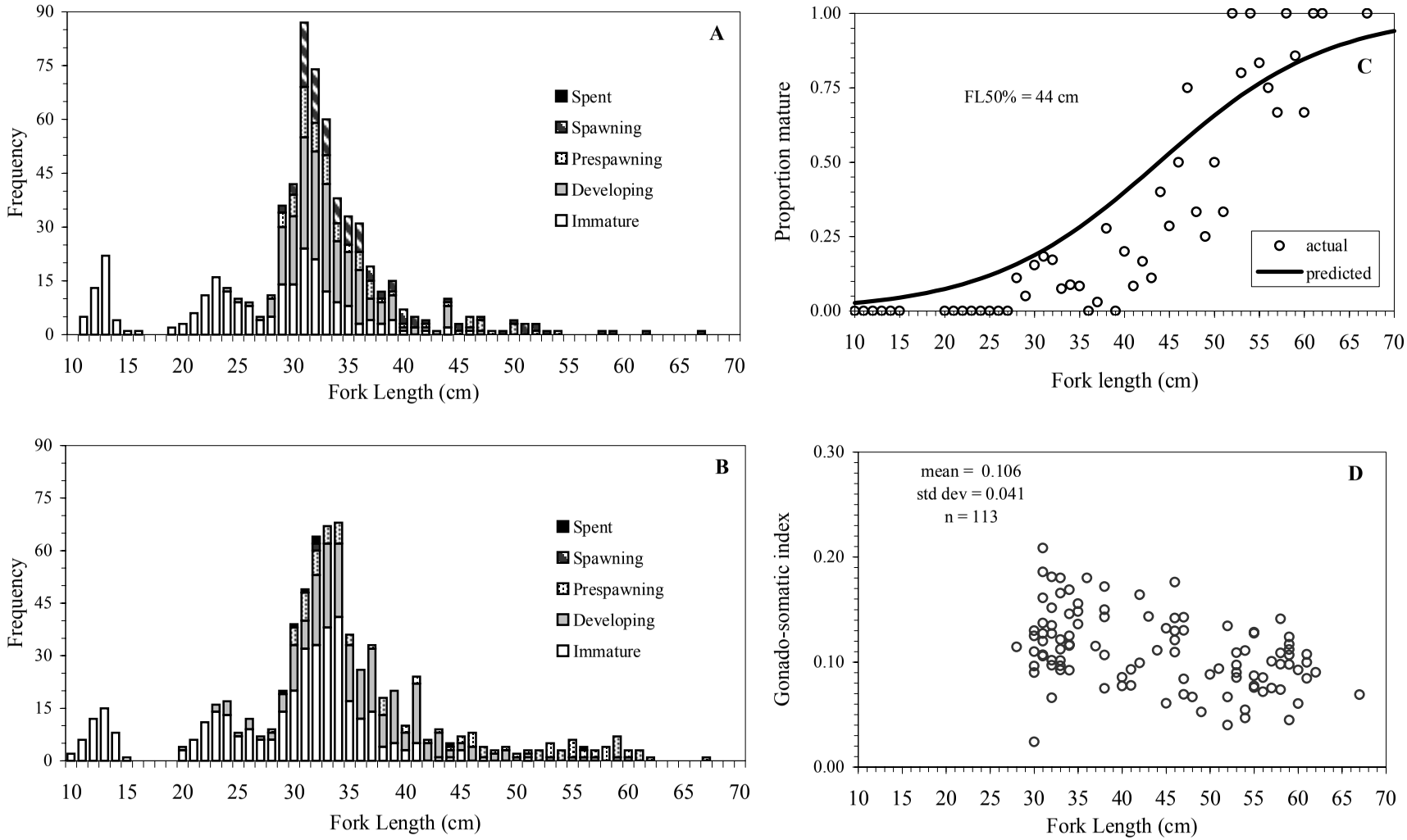

Figure 14. Maturity stages for (A) male and (B) female pollock, (C) fitted logistic function and proportion mature by 1-cm size class for female pollock. and (D) average gonadosomatic index for pre-spawning females examined during the winter 2003 echo integraton-trawl survey of Shelikof Strait in the Gulf of Alaska.

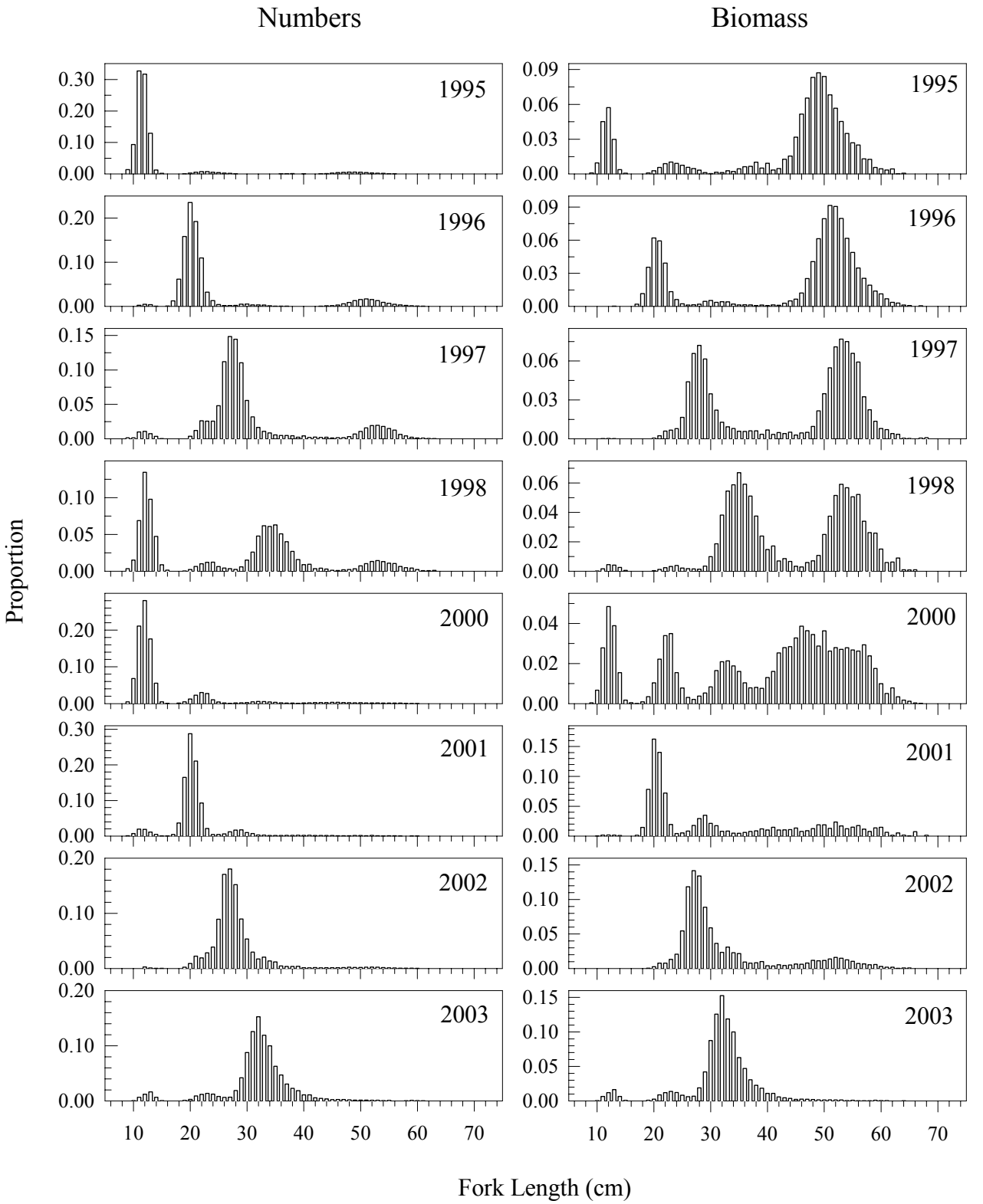

Figure 15. Annual pollock size composition estimates for the Shelikof Strait area based on echo integration-trawl surveys conducted from 1995 to 2003. Note: area was not surveyed in 1999.

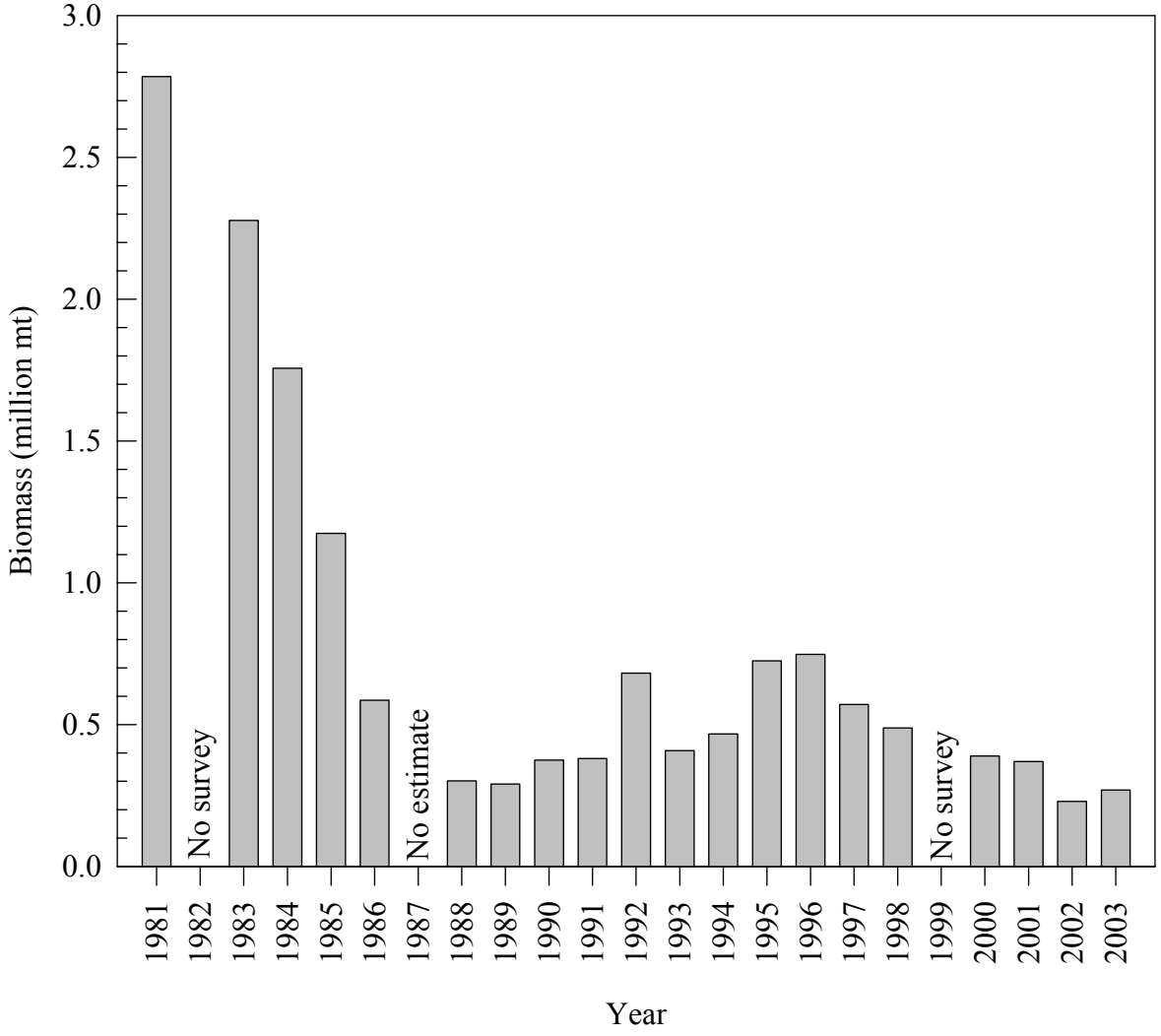

Figure 16. Summary of annual pollock biomass estimates based on echo integration-trawl surveys of the Shelikof Strait area.

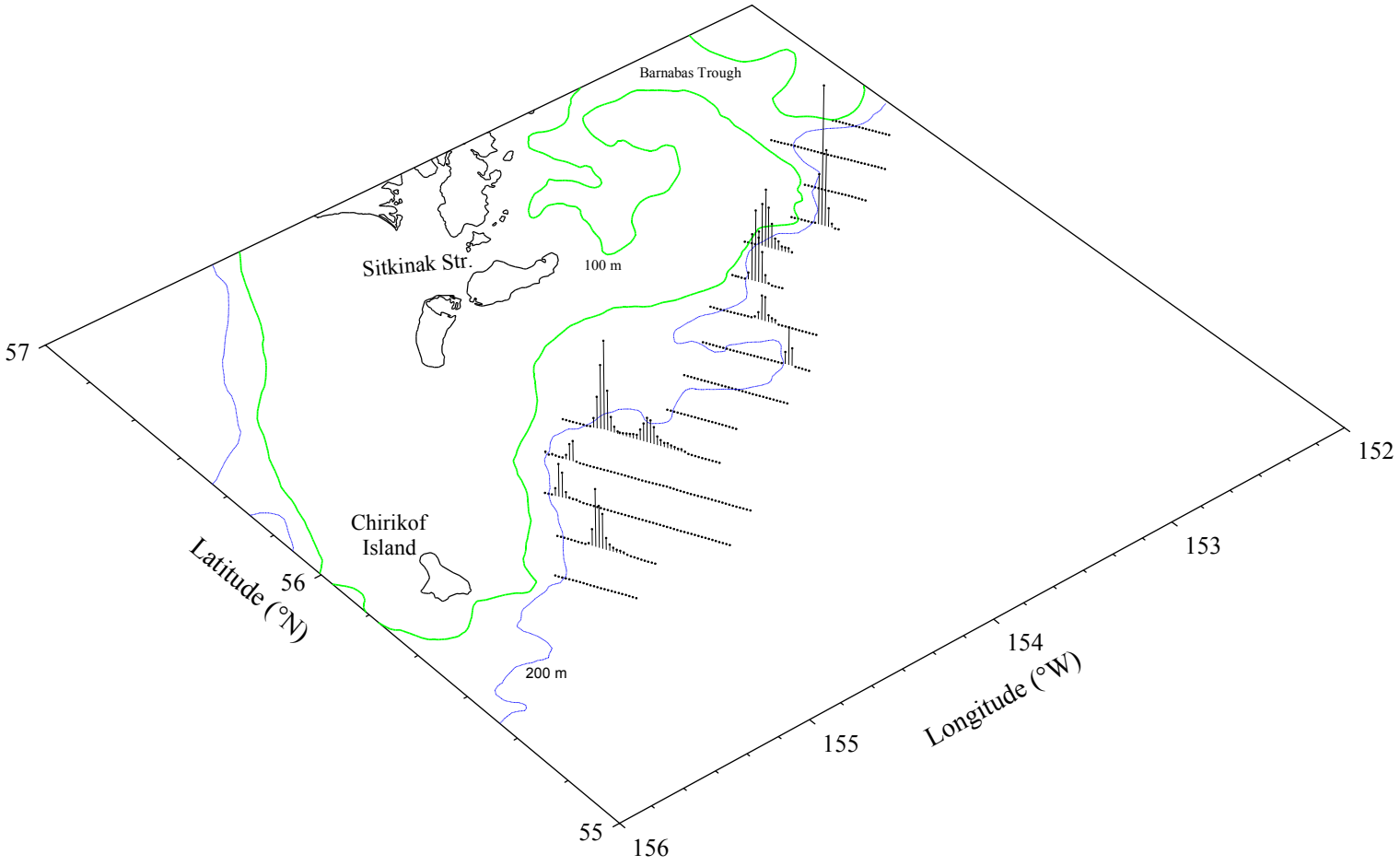

Figure 17. Relative pollock backscatter (s_A) along transects from the 2003 winter echo integration-trawl survey of the Gulf of Alaska shelf break near Chirikof Island.

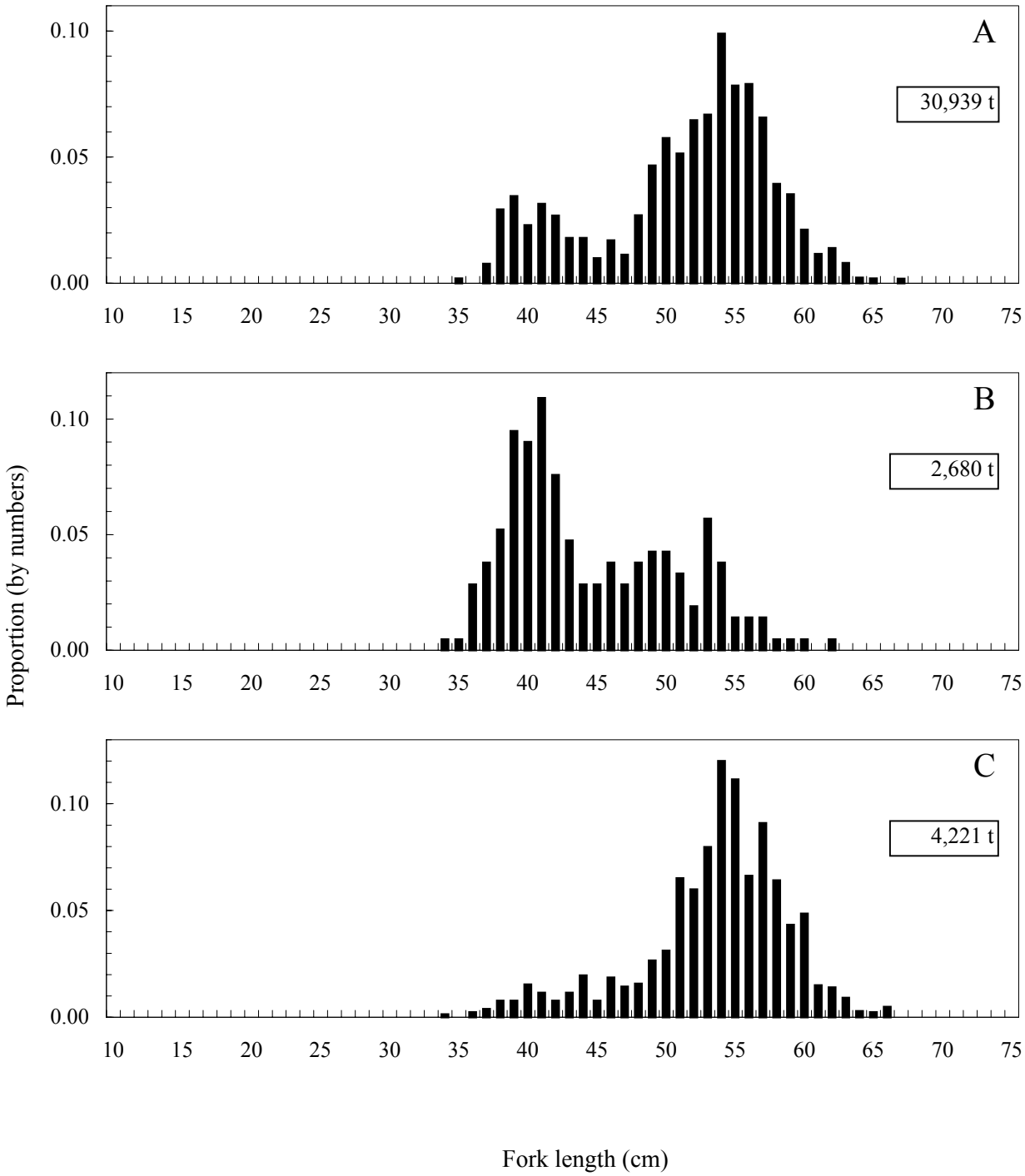

Figure 18. Estimates of pollock size distribution (numbers of fish) and biomass (metric tons (t)) of the shelf-break area (A) near Chirikof Island, (B) west of Middleton Island and (C) east of Middleton Island during the March 2003 echo integration-trawl surveys in the Gulf of Alaska.

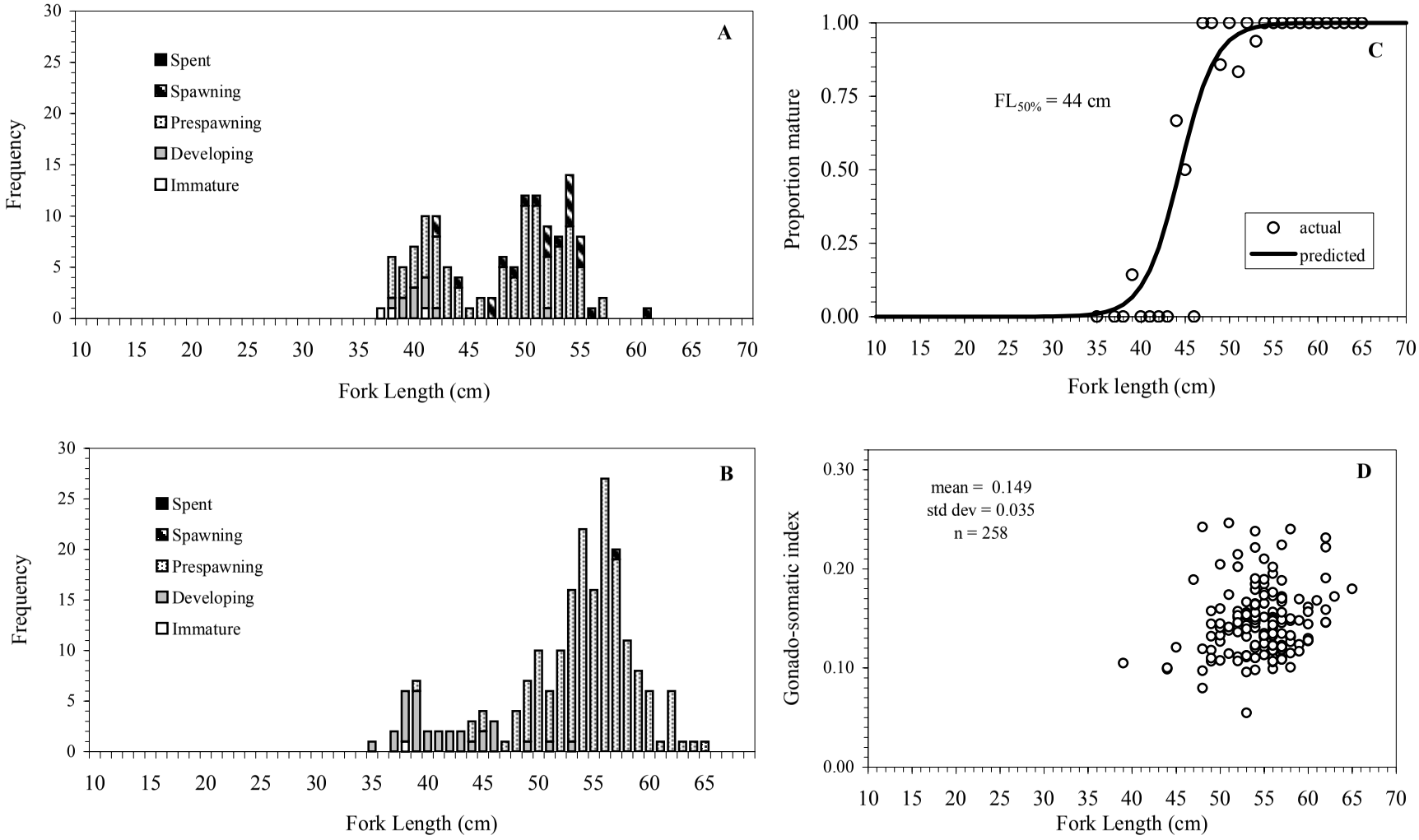

Figure 19. Maturity stages for (A) male and (B) female pollock, (C) fitted logistic function and proportion mature by 1-cm size class for female pollock. and (D) average gonadosomatic index for pre-spawning females examined during the winter 2003 echo integraton-trawl survey of the Chirikof Island area in the Gulf of Alaska.

Pollock Acoustic Backscatter (s_A)
NOAA Ship *Miller Freeman*
28-29 March, 2003

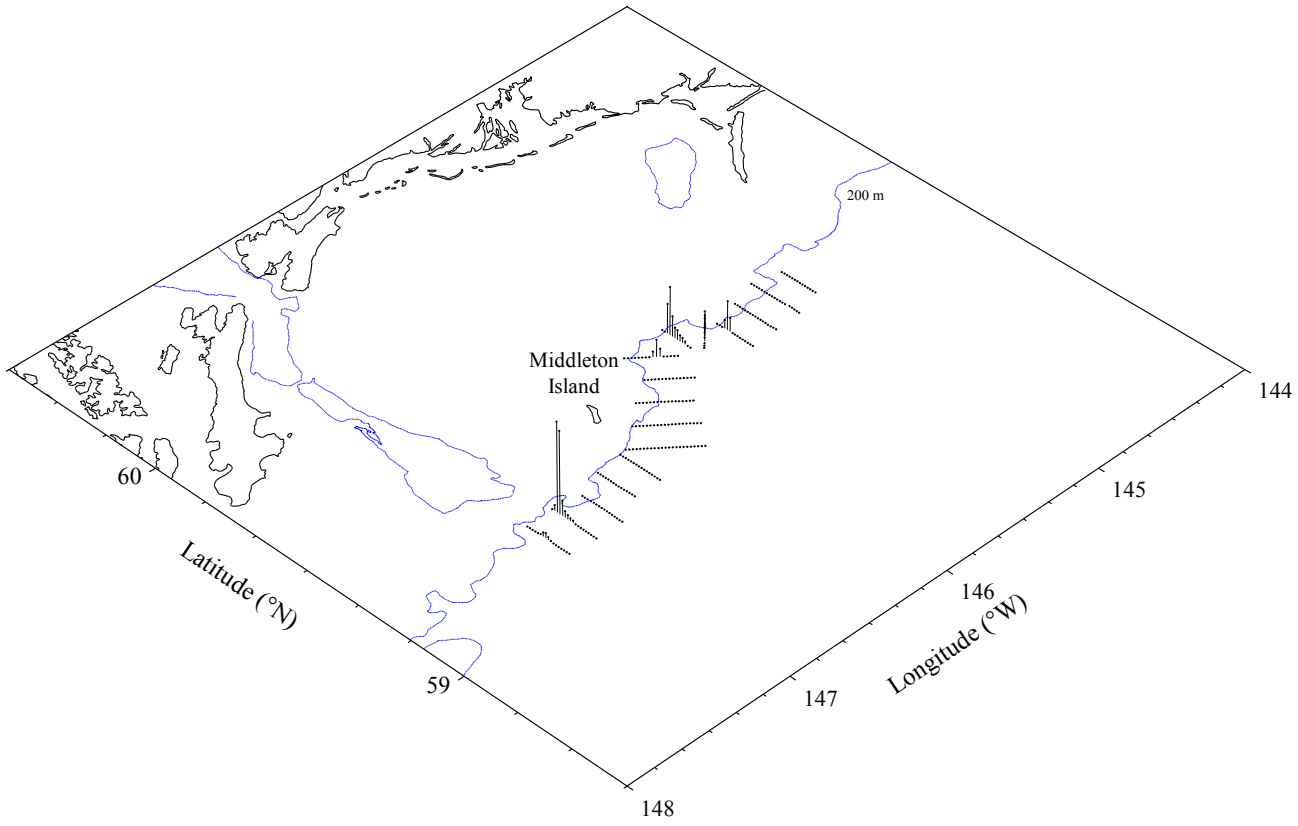

Figure 20. Relative pollock backscatter (s_A) along transects from the 2003 echo integration-trawl survey of the Gulf of Alaska shelf break near Middleton Island.

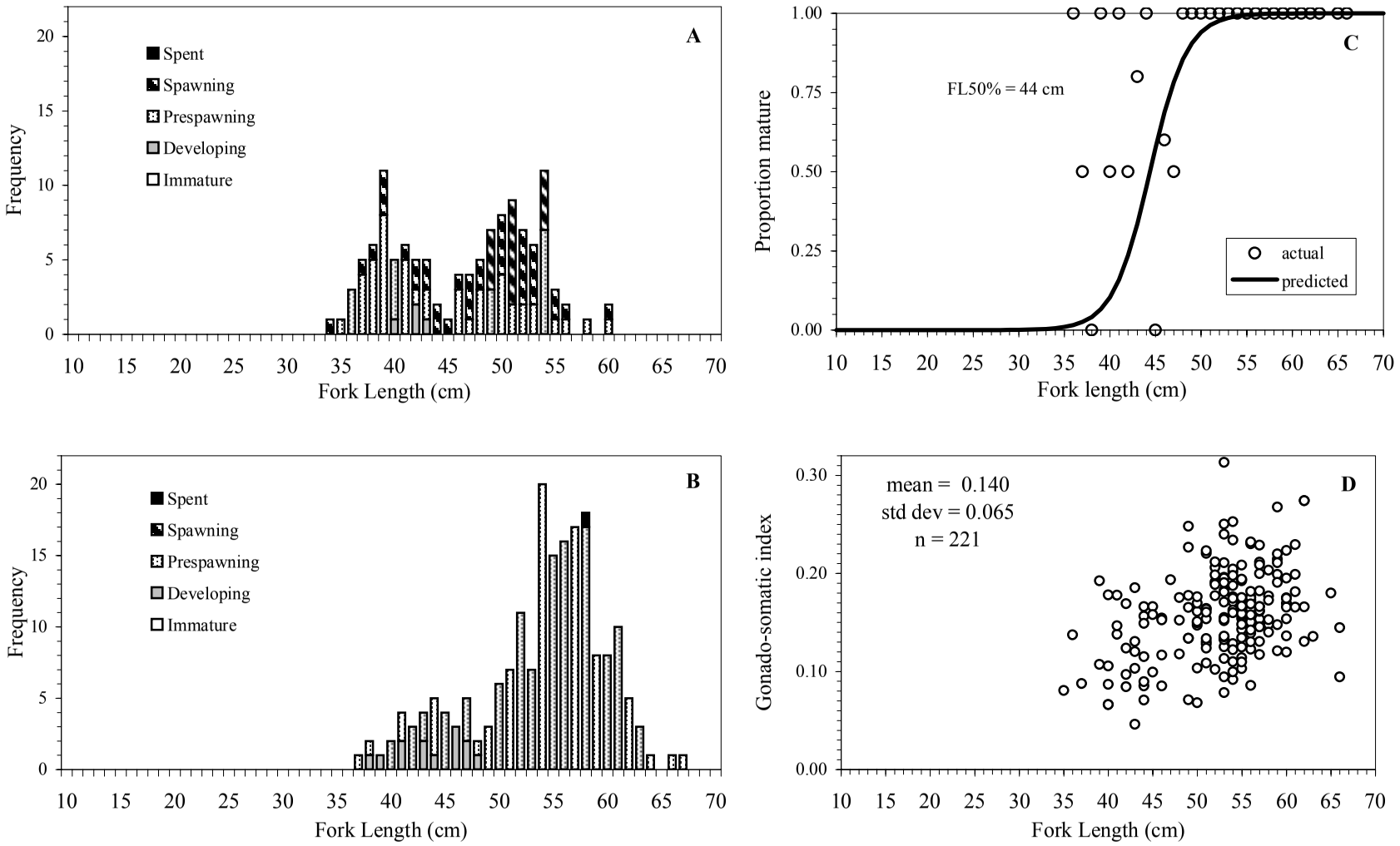

Figure 21. Maturity stages for (A) male and (B) female pollock, (C) fitted logistic function and proportion mature by 1-cm size class for female pollock. and (D) average gonadosomatic index for pre-spawning females examined during the winter 2003 echo integraton-trawl survey of the Middleton Island area in the Gulf of Alaska.

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